Sri Dev Suman Uttarakhand University, Badshahithaul, Tehri (Garhwal), Uttarakhand-249199

NATIONAL EDUCATION POLICY-2020

Syllabus for Sri Dev Suman Uttarakhand University Campus and all Affiliated Colleges

STRUCTURE OF PG - CHEMISTRY SYLLABUS 2023

BOARD OF STUDIES IN CHEMISTRY

Name	Responsibility	Phone No.	Signature
Prof. Gulshan Kumar Dhingra Dean of Science Pt. LMS Campus (SDSU University), Rishikesh	Convener	7017976632	
Prof. S.P. Sati HOD, Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	6395571797	
Prof. Neeta Joshi Professor Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	9412982875	
Prof. Ashish Sharma Professor Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	9719713300	
Prof. Hitendra Singh Professor Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	9411774356	
Dr. Vibha Singh Associate Professor Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	9410371168	
Dr. Seema Associate Professor Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	~~58138438~~ 9258138438	11/07/23
Dr. Rakesh Kumar Joshi Assistant Professor Department of Chemistry, Pt. LMS Campus (SDSU University), Rishikesh	Member	9412441598	
External Subject Experts			
Prof. Chitra Pande HOD, Department of Chemistry, Kumaun University, Naintital		9720135762	
Prof. Veena Joshi Professor, Department of Chemistry, HNB Garhwal Central University SRT Campus, Badsahithaul, Tehri		9412914790	

Garhwal			
PG Principals			
Prof. Pushpa Negi Principal Govt. P.G. College, Augustayamuni, Rudraprayag			
Prof. Pankaj Pant Principal Govt. P.G. College, Nagnath Pokhari, Chamoli		8941973018	11.7.2023
Prof. Kuldeep Singh Negi Principal Govt. P.G. College, Khanpur, Haridwar			11.07.2023
Research Institution Director			
Director, USERC, Dehradun			11.07.23

Semester-wise Titles of the Papers in M.Sc. Chemistry

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Bachelor (Research) in Chemistry					
4 M.Sc. I YEAR	**VII / Ist Sem**	**MSCHE 101**	Advanced Inorganic Chemistry-I	Theory	4
		MSCHE 102	Advanced Organic Chemistry- I	Theory	4
		MSCHE 103	Advanced Physical Chemistry-I	Theory	4
		MSCHE 104	Group Theory and Spectroscopy	Theory	4
		MSCHE 105	Advanced Experimental Chemistry-I	Practical-4	4
		MSCHE 106	Industrial Training / Research Project	Major	4
	VIII / IInd Sem	**MSCHE 201**	Advanced Inorganic Chemistry-II	Theory	4
		MSCHE 202	Advanced Organic Chemistry-II	Theory	4
		MSCHE 203	Advanced Physical Chemistry-II	Theory	4
		MSCHE 204	Spectroscopic Techniques-I	Theory	4
		MSCHE 205	Advanced Experimental Chemistry-II	Practical -4	4
		MSCHE 206	Industrial Training / Research Project	Major	4
	VII or Ist sem / VIII or IIndSem	**MSCHE 207(i) / (ii) / (iii) / (iv) / (v)**	**Minor Elective (Any one paper out of five options)**	Minor	4
TOTAL CREDIT ..... (24 + 24 + 4) = 52 for Ist year M.Sc Chemistry					
Master in Chemistry					
5 M.Sc. II YEAR	**IX / IIIrd Sem**	**MSCHE 301**	Solid State Chemistry	Theory	4
		MSCHE 302	Interdisciplinary Topics in Chemistry	Theory	4
		MSCHE 303	Pericyclic Reactions and Photochemistry	Theory	4
		MSCHE 304	Chemistry for Biological System	Theory	4
		MSCHE 305	Advanced Experimental Chemistry-III	Practical -5	4

	IX / IIIrd Sem	MSCHE 306	Industrial Training / Research Project	Major	4
	X / IVth Sem	MSCHE 401	Spectroscopic Techniques-II	Theory	4
		MSCHE 402	Analytical Techniques	Theory	4
		MSCHE 406	Research/ project work Instrumental training/Industrial training	Hands-on-training	4
		Inorganic Chemistry Group			
		MSCHEIN 403	Inorganic Polymers	Theory	4
		MSCHEIN 404	General and Organometallic Chemistry	Theory	4
		MSCHE405	Advanced Experimental Chemistry-IV (Inorganic)	Practical -5	4
		Organic Chemistry Group			
		MSCHEORG 403	Organic Synthesis	Theory	4
		MSCHEOORG 404	Chemistry of Natural Products and Heterocyclic Compounds	Theory	4
		MSCHE405	Advanced Experimental Chemistry-IV (Organic)	Practical -5	4
		Physical Chemistry Group			
		MSCHEPHY 403	Physical Organic and Quantum Chemistry	Theory	4
		MSCHEPHY 404	Advanced Chemical Dynamics and Thermodynamics	Theory	4
		MSCHE405	Advanced Experimental Chemistry –IV (Physical)	Practical -5	4
TOTAL CREDIT		24+24 = **48 For IInd Year M.Sc. Chemistry**			

Purpose of the Program

The Importance of chemistry arises because so many other disciplines draw on certain chemical principles and concepts. The purpose of the postgraduate chemistry program at the university and

college level is to prepare our students for all those fields where knowledge of chemistry is required including academia for careers as professionals in various industries and research institutions.

Program's Outcomes

PO 1. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in analytical, inorganic, organic and physical chemistry.

PO 2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

PO 3. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO 4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

PO 5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.

PO 6. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

PO 7. Students will be able to function as a member of an interdisciplinary problem-solving team.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
BACHELOR (RESEARCH) IN CHEMISTRY	
Fourth Year	Bachelor (Research) in Chemistry programme aims to introduce very important aspects of modern-day course curriculum, namely, 1.stereochemistry and bonding in main group compounds including compounds of boron, carbon and nitrogen with metals, metal-ligand equilibria in solution, metal -acid complexes, cluster compounds, polyoxometalates, nature of bonding in organic molecules, stereochemistry, pericyclic reactions, nucleophilic substitution reaction, mechanism of carbocation rearrangement, zero, first, second and third law of thermodynamics and their applications, concept of free energy, spontaneity, fugacity, thermodynamics of non-ideal solutions, experimental methods for kinetic studies, viz; conductometric, potentiometric and spectrophotometric methods, effect of temperature on rate of reaction, Arrhenius equation, kinetics of gaseous reactions on solid surface, condensation and addition polymerization reactions, symmetry and group theory in chemistry, x-ray diffraction, electron diffraction, chromatographic methods, radio analytical methods. This knowledge will make the students skilled to work in various chemical industries like cement industries, agro product, paint industries, rubber industries, petrochemical industries, food processing industries, fertilizer industries, pollution monitoring and control agencies etc. It will also enable the students to understand the importance of the biomolecules and the industrially important compounds including their physical and chemical nature and role in the daily life and also to understand the concept of chemistry to inter relate and interact to the other subject like mathematics, physics, biological science etc.
Fifth Year	Degree in Master of Science programme aims to introduce very important aspects of modern-day course curriculum, namely, medicinal chemistry, polymer chemistry, environmental chemistry, bioinorganic, bio-organic, organometallic, reagents in organic synthesis, nano chemistry, green chemistry, natural products and spectroscopic techniques. This knowledge will make the students skilled to work in various chemical industries like cement industries, agro product, paint industries, rubber industries, petrochemical industries, food processing industries, fertilizer industries, pollution monitoring and control agencies etc. It will also enable students for industrially important compounds including their physical and chemical nature and role in the daily life and also to understand the concept of chemistry to inter relate

	and interact to the other subject like mathematics, physics, biological science etc. Upon completion of a degree, chemistry students will able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program. Various research institutions and industry people in the pharmaceuticals, polymers, and food industry sectors will surely value this course.

Subject: Chemistry							
Year	**Semester**	**Theory Paper**	**Units**	**Practical Paper**	**Units**	**Research Project**	**Total Credits of the Year subject**
4	VII / **Ist Sem**	Advanced Inorganic Chemistry-I	1. Stereochemistry and Bonding in Main Group Compounds including Compounds of Boron, Carbon and Nitrogen with Metals 2. Substitution Reactions of Square Planar Complexes 3. Metal π-Acid Complexes: 4. Cluster Compounds	Advanced Experimental Chemistry -I	1. Laboratory hazards and safety precautions 2. Inorganic Mixture Analysis 3. Inorganic Compound Synthesis/Quantitative estimation 4. Organic Quantitative Analysis 5. Spectroscopic Estimations/ Organic Qualitative Analysis	Research Project	4+4+4+4+4+4 =24
		Advanced Organic Chemistry-I	1. Fundamentals of Reaction Mechanism 2. Reaction Intermediates 3. Stereochemistry A 4. Stereochemistry B				
		Advanced Physical Chemistry-I	1. Thermodynamics-I 2. Thermodynamics-II 3. Chemical Dynamics				
		Group Theory and Spectroscopy	1. Symmetry and Group Theory 2. Electromagnetic spectrum 3. Microwave spectroscopy 4. Energy of atomic orbitals				
	VIII / **IInd Sem**	Advanced Inorganic Chemistry-II	1. Reaction Mechanism of Transition Metal Complexes I 2. Reaction Mechanism of Transition Metal Complexes II 3. Electronic Spectra of Transition Metal Complexes	Advanced Experimental Chemistry –II	1. Prelab Exercises related to physical and organic Experiments 2. Organic Chemistry 3. Physical Chemistry	Research Project	4+4+4+4+4+4 =24
		Advanced Organic Chemistry-II	1. Reaction Mechanism-I 2. Reaction Mechanism-II 3. Name Reactions				

		Advanced Physical Chemistry-II	1. Surface Chemistry 2. Chemical Dynamics 3. Advanced Quantum Chemistry				
		Spectroscopic Techniques-I	1. Nuclear Magnetic Resonance Spectroscopy 2. Mass Spectrometry 3. Infrared Spectroscopy				
	VII or Ist sem / VIII or IIndSem	MINOR PAPER	Any one of five minor electives		1. Environmental Chemistry 2. Medicinal Chemistry 3. Biology for Chemist (for maths Stream students) 4. Mathematics for Chemist (For Bio stream students) 5. Interdisciplinary topic in Chemistry		4
TOTAL CREDIT FOR M.Sc. I YEAR (VII AND VIII SEMESTER) ……**52**							
5	IX / **IIIrd Sem**	Solid State Chemistry	1. Solid State Reactions, Crystal Defects and Non-stoichiometry 2. Electronic Properties and Band theory 3. Organic Solids, Fullerenes, Molecular Devices	Advanced Experimental Chemistry –III	1. Pre-labs 2. Inorganic Chemistry 3. Physical Chemistry Practical exercises	Research Project	4+4+4+4+4+4 =24
		Inter Disciplinary Topics of Chemistry	1. Green Chemistry 2. Nanochemistry 3. Environmental Chemistry				
		Pericyclic Reactions and Photochemistry	1. Pericyclic Reactions 2. Basics of Photochemistry 3. Photochemistry of Organic Compounds				

		Chemistry for Biological System	1. Bioinorganic Chemistry 2. Bioorganic Chemistry 3. Biophysical Chemistry				
	X / IV^{rth} Sem	Spectroscopic Techniques-II	1. Electron Spin Resonance Spectroscopy 2. Mossbauer Spectroscopy 3. Raman Spectroscopy	Advanced Experimental Chemistry -IV		Research Project/Hands on Training on Various Instruments.	4+4+4+4+4+4 =24
		Analytical Techniques	1. X ray 2. Chromatography 3. Radioanalytical 4. Extraction				
		Inorganic Chemistry Group			1. Laboratory hazards and safety precautions 2. Three component gravimetric analysis 3. Inorganic mixture analysis by semimicro method		
		Inorganic Polymers	1. Basics of Inorganic Polymers 2. Structure and Properties 3. Polymer Characterization				
		General and Organometallic Chemistry	1. Organic Derivatives of Metals and Alkyls, Aryls and Acyls of Metals. 2. Compounds of Metal-Carbon Multiple Bonds and Fluxional Organometallic Compounds Catalysis Mechanism of Some Reactions 3. Catalysis Mechanism of Some Reactions				
		Organic Chemistry Group			1. Laboratory hazards and safety precautions 2. Separation, purification and identification of the components of a mixture of three organic compounds/ Extraction of Organic		
		Organic Synthesis	1. Oxidation 2. Reduction 3. Disconnection Approach, One group C-C Disconnections and Two Group C-C Disconnections				

		Chemistry of Natural Products and Heterocyclic Compounds	1. Terpenoids, Carotenoids, Alkaloids and Steroids 2. Plant Pigments / Porphyrins 3. Heterocyclic Chemistry		Compounds from Natural Sources 3. Spectroscopy		
		Physical Chemistry Group			1. Laboratory hazards and safety precautions 2. Physical Chemistry Quantitative Exercise		
		Physical Organic and Quantum Chemistry	1. Advanced Quantum Mechanics 2. Concepts in Molecular Orbital (MO) Theory 3. Supramolecular Chemistry				
		Advanced Chemical Dynamics and Thermodynamics	1. Advanced Chemical Dynamics 2. Kinetics in Solution 3. Fast Chemical Reactions				
TOTAL CREDIT FOR M.Sc. II YEAR (**IX^th AND X^th** SEMESTER) **48**							

Subject: Chemistry						
Course	**Semester**	**Paper Title**		**Prerequisite for Paper**	**Hours per Semester**	**Total Credits of the Year subject**
achelor (esearch) in hemistry	VII	Theory-1	Advanced Inorganic Chemistry-I	Passed Degree in Bachelor of Science with Chemistry as major subject	60	4
	M.Sc I st	Theory-2	Advanced Organic Chemistry-I	Passed Degree in Bachelor of Science with Chemistry as major subject	60	4
		Theory-3	Advanced Physical Chemistry-I	Passed Degree in Bachelor of Science with Chemistry as major subject	60	4
I.Sc Ist ear		Theory-4	Group Theory and Metal Ligand Bonding	Passed Degree in Bachelor of Science with Chemistry as major subject	60	4
		Practical-5		Passed Degree in Bachelor of Science with	120	4

Pattern of examination theory papers

A. Theory

Each theory paper shall consist two sections A and B.
***Section A:** (Short answers type with reasoning); 25 marks, eight questions of five marks each, any five have to be attempted).*
***Section B:** (Long answers type);50 marks, one question of ten marks each. Five questions are compulsory (each question from each unit) with internal choice.*

B. Internal assessment

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/ the Principal of the College for uploading onto the University examination portal.

C. Practical

The laboratory work of the students has to be evaluated periodically. The internal assessment (in the form of lab test, lab record, internal evaluation, assignment/home assignment and attendance) of total 25 marks for each semester shall be conducted during the semester. A minimum of 12 experiments covering all kinds of exercises have to be conducted during a semester. Maximum 15 marks of attendance and 10 marks of record and overall performance can be given to the students. In each semester practical examination of 75 marks has to be conducted by two examiners (External and internal) having duration of 2 days (6 hours each day) for I to IV Semester. The total number of students to be examined per batch should not be more than sixty. Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, SriDev Suman Uttarakhand University , Badshahithaul.

D. Specialization

Affiliated Colleges interested in more than one Specialization within course in specified semester can opt with the permission of Head of the Department of the Campus / Course Convenor in the Chemistry Department.

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Bachelor (Research) in Chemistry					
4 / M.Sc. I Year	**VII / M.Sc. Ist Semester**	**MSCHE 101**	Advanced Inorganic Chemistry-1	Theory	4
		MSCHE 102	Advanced Organic Chemistry-1	Theory	4
		MSCHE 103	Advanced Physical Chemistry-I	Theory	4
		MSCHE 104	Group Theory and Spectroscopy	Theory	4
		MSCHE 105	Advanced Experimental Chemistry-I	Practical	4
		MSCHE 106	Research Project	Research	4
4 / M.Sc. I Year	**VIII / M.Sc. IInd Semester**	**MSCHE 201**	Advanced Inorganic Chemistry-II	Theory	4
		MSCHE 202	Advanced Organic Chemistry-II	Theory	4
		MSCHE 203	Advanced Physical Chemistry-II	Theory	4
		MSCHE 204	Spectroscopic Techniques- I	Theory	4
		MSCHE 205	Advanced Experimental Chemistry-II	Practical	4
		MSCHE 206	Research Project	Research	4
4 / M.Sc. I Year	**VII OR VIII / I Or II**	**MSCHE 207(i)/ (ii)/(iii)/ (iv)/(v)**	Minor Elective	Theory	4

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Bachelor (Research) in Chemistry					
5 / M.Sc. II Year	IX / M.Sc. IIIrd Semester	MSCHE 301	Solid State Chemistry	Theory	4
		MSCHE 302	Spectroscopic Techniques II	Theory	4
		MSCHE 303	Pericyclic reactions and Photochemistry	Theory	4
		MSCHE 304	Chemistry for Biological System	Theory	4
		MSCHE 305	Advanced Experimental Chemistry-III	Practical	4
		MSCHE 306	Research Project	Research	4
5 / M.Sc. II Year	X / M.Sc. IV^{rth} Semester	MSCHE 401	Spectroscopic Techniques III	Theory	4
		MSCHE 402	Analytical Techniques	Theory	4
		MSCHE 405	Advanced Experimental Chemistry-IV	Practical	4
		MSCHE 406	Research / Project Project	Research	4
	X / M.Sc. IV^{rth} Semester	MSCHEIN 403	Inorganic Polymers	Theory	4
		MSCHEIN 404	General and Organometallic Chemistry	Theory	4
		MSCHEORG 403	Organic Synthesis	Theory	4
		MSCHEORG 404	Chemistry of Natural Products and Heterocyclic Compounds	Theory	4
		MSCHEPHY 403	Physical organic and Quantum Chemistry	Theory	4
		MSCHEPHY 404	Advance Chemical dynamics and Thermodynamics	Theory	4

Semester-VII
Paper-I (Theory) MSCHE 101
Course Title: Advanced Inorganic Chemistry-I

Programme/Class: Bachelor (Research) in Chemistry	Year: Fourth	Semester: Seven
		Paper-2 Theory Subject: Chemistry
Course Code:	Course Title: Advanced Inorganic Chemistry-I	

Course outcomes: Upon successful completion of this course, the students will be able to describe the stereochemistry and bonding in main group compounds, stability of coordination compounds and factors affecting the stability of metal complexes. They will also learn about the structure, bonding and reaction chemistry of metal carbonyls, cluster compounds and polyoxometalates.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Content	Number of lectures
1	**Stereochemistry and Bonding in Main Group Compounds including Compounds of Boron, Carbon and Nitrogen with Metals** **(a) Stereochemistry and Bonding in Main Group Compounds** Hybridization, Isovalent hybridization, Drago Rule, Bent rule, its applications and energetics of hybridization, Walsh Diagram (AB_2, AB_3 and AB_4 molecule), some simple reactions of covalently bonded molecules (Atomic inversion, Berry pseudorotation, nucleophilic substitution reactions, free radical mechanism). **(b) Compounds of Boron, Carbon and Nitrogen with Metals:** Metal borides, carbides and nitrides: preparation, properties, structures and application.	**10**
2 1.	**Substitution Reactions of Square Planar Complexes:** Substitution reactions in square planar complexes: Types, mechanism, potential energy diagrams, transition states and intermediates. Factors affecting the substitution reaction. *Trans* effect and its applications in synthesis of complexes, theories of *trans* effect.	**10**
3 2.	**Metal π-Acid Complexes:** Metal carbonyls: Introduction, preparation, properties, reactions, bonding and vibrational spectra. Metal nitrosyls: Preparation, properties, reactions, structure, bonding and vibrational spectra. EAN and 18-rule rule. Complexes of dinitrogen, dioxygen and tertiary phosphine	**10**

4	**Metal-Ligand Bonding:** Sigma bonding in octahedral complexes: Classification of metal valence orbitals into sigma symmetry, formation of ligand group orbitals (LGOs) of sigma symmetry, Formation of molecular orbitals of sigma symmetry, construction of molecular orbital energy level diagram involving only sigma bond contribution from ligands, pi bonding in octahedral complexes: Classification of metal valence orbital into pi symmetry, Formation of LGOs of pi symmetry. Formation of pi MOs and construction of molecular orbital energy level diagram involving sigma and pi contribution from pi donor ligands, Sigma and pi bonding in tetrahedral complexes and square planar complexes.	**15**
5 3.	**Cluster Compounds:** Introduction, classification, higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and metal halide clusters. Clusters with metal-metal multiple bonds. Electron counting in clusters (Wade's rule), Isolobal analogy.	**15**

Books Recommended:

i. F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, John Wiley & Sons, New York, 2003.
ii. J. D. Lee, Concise Inorganic Chemistry, Fifth Edition, Wiley India, 2012.
iii. Atkins, Overton, Rourke, Weller and Armstrong, Inorganic Chemistry, Oxford University Press.
iv. J. E. Huheey, E. A Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, Fourth Edition, Pearson Education, 2003.
v. W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier.
vi. G. Wulfsberg, Inorganic Chemistry, Viva Books.
vii. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Pearson Education.

Suggested online links:

https://nptel.ac.in/courses/104/106/104106089/
http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000658/M014009/ET/1456899566CHE_P3_M5_etext.pdf
http://ddugu.ac.in/epathshala_content1.aspx
https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf
https://nptel.ac.in/courses/104/106/104106064/
https://www.youtube.com/watch?v=bsfMa1nwNEw&list=PLmxSS9XYst21Z1kmeqDbVZM6lp-RWSWIo
https://www.youtube.com/watch?v=keoaaCXmUJo&list=PLmxSS9XYst22ylDk1NOSmCLA-l9X7xTzh
https://www.youtube.com/watch?v=JbPvMNIedf8&list=PLmxSS9XYst22VQmOe6CFkXqAjPtCCDg6O
https://www.youtube.com/watch?v=zUwbVaBaxTY&list=PLmxSS9XYst227ymEa_ovzDf7xs8snXlRp
https://www.youtube.com/watch?v=9oQcm281TT0&list=PLmxSS9XYst22B6gnqyEAx7RIA4Lqu3nmf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had passed degree in Bachelor of Science with Chemistry as major subject.

Semester-VII
Paper-2 (Theory) MSCHE 102
Course Title: Advanced Organic Chemistry-1

Programme/Class: Bachelor (Research) in Chemistry	**Year:** Fourth	**Semester:** Seven
		Paper-2 Theory Subject: Chemistry
Course Code:	**Course Title:** Advanced Organic Chemistry-1	

Course Outcomes: Upon successful completion of this course, the students should be able to describe the nature of bonding in organic molecules and their stereochemistry. They can able to understand the stereoselectivity, stereospecificity, regioselectivity, chemo selectivity, enantiomeric and diastereomeric excess. They can describe the mechanism of carbocation rearrangement reactions. This course aims to introduce the students with basic understanding of chemical bonding in organic molecules, their stereochemistry during undergoing reactions.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	**Contents**	**Number of Lectures**
1 1.	**Fundamentals of Reaction Mechanism:** Classification of chemical reactions; kinetic and thermodynamic consideration of chemical reactions; Hammond's postulate, Transition state theory-Curtin-Hammett principle, methods of determining reaction mechanisms. Effects of structure on reactivity – resonance and	**8**

	field effects, steric effect, quantitative treatments. Hammett equation and linear free energy relationship, substituent and reaction constants.	
2 2. 3.	**Reaction Intermediates:** Carbocations: Classical and non-classical (phenonium ions, norbornyl system), neighbouring group participation by π and σ bonds, ion-pairs, molecular rearrangements (Wagner-Meerwein rearrangement, Pinacol-pinacolone rearragenement, Benzilic acid rearrangement, Arndt-Eistert synthesis, Demjanov reaction. stability and reactivity of bridge-head carbocations, nature of migration, migratory aptitude, memory effects. Carbanions: Generation, structure and stability, ambident ions and their general reactions (Aldol, Claisen, Wittig and Mannich reaction, Shapiro reaction, Favorskii rearrangement). Free Radicals: Generation, structure, stability and reactions, cage effects; radical-cations & radical anions, types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, autooxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Carbenes: Formation and structure, reactions involving carbenes (Reimer Tiemann reaction, ring expansion). Nitrenes: Generation, structure and reactions of nitrenes (Neber, Curtius, Schmidt reactions). Arynes: Generation and reactivity of arynes, nucleophilic aromatic substitution reactions, SNAr mechanism; Ipso effect.	**20**
3 4.	**Stereochemistry A:** Molecular symmetry and chirality: symmetry operations and symmetry elements, point group classification and symmetry number. Stereoisomerism: Classification, racemic modification, molecules with one, two or more chiral centres. Configuration, nomenclature, D, L, R, S and E, Z nomenclature. Axial and planar chirality and helicity (P & M); stereochemistry and configurations of allenes, spiranes, alkylidene, cycloalkanes, adamantanes, catenanes, biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes.	**12**
4	**Stereochemistry B:** Topicity and prostereoisomerism: Topicity of ligands and faces and their nomenclature, stereogenicity, cyclostereoisomerism; configurations, conformations and stability of cyclohexanes, (mono-, di- and tri-substituted), cyclohexenes, cyclohexanones, halocyclohexanones, decalins, decalols,	**20**

	decalones. Asymmetric induction; Cram's, Prelog's and Horeaus rules. Dynamic stereochemistry (cyclic and acyclic). Qualitative correlation between confirmation and reactivity- Curtin-Hammitt principle. Stereochemistry of compounds containing N, S and P. chirogenicity, pseudoasymmetry and stereogenic centre. Stereoselectivity, stereospecificity, regioselectivity and chemoselectivity. Enantiomeric and diastereomeric excess.	

Books Recommended:

i. Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
ii. R. T. Morrison and R. N. Boyd, Organic Chemistry, Prentice Hall.
iii. C. K. Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
iv. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan.
v. D. Nasipuri, Stereochemistry of Organic Compounds, New Age International
vi. P. S. Kalsi, Stereochemistry of Organic Compounds, New Age International.
vii. S. M. Mukherjee, Pericyclic Reactions, Macmillan, India.
viii. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Plenum.
ix. Benjamin , Modern Organic Reactions, HO House.
x. Ernest L. Eliel and Samuel H. Wilen, Stereochemistry of Organic Compounds, Wiley India
xi. Ernest L. Eliel, Stereochemistry of Carbon Compounds. Tata McGraw Hill.

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://nptel.ac.in/courses/104/106/104106127/
https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy25/
https://onlinecourses.swayam2.ac.in/ugc19_ch01/preview
https://www.uou.ac.in/lecturenotes/science/MSCCH-17/CHEMISTRY%20LN%201%20STERIOCHEMISTRY.pdf
https://nptel.ac.in/courses/104/101/104101005/
https://nptel.ac.in/courses/104/106/104106077/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had Passed Degree in Bachelor of Science with Chemistry as major subject.

Semester-VII
Paper-3 (Theory) MSCHE 103
Course Title: Advanced Physical Chemistry-1

Programme/Class: Bachelor (Research) in Chemistry	**Year:** Fourth	**Semester:** Seven
	Paper-3 Theory Subject: Chemistry	
Course Code:	**Course Title:** Advanced Physical Chemistry-1	

Course Outcomes: This paper provides detailed knowledge of the zero, first, second and third law of thermodynamics and their applications, concept of free energy, spontaneity, fugacity etc. Upon successful completion of this course, the students should be able to describe the thermodynamics of non-ideal solutions, experimental methods for kinetic studies, *viz*; conductometric, potentiometric and spectrophotometric methods, effect of temperature on rate of reaction, Arrhenius equation, kinetics of gaseous reactions on solid surface, condensation and addition polymerization reactions.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1 1.	**Advanced Thermodynamics-I:** Laws of thermodynamics: Fundamental concepts, state and path dependent functions, determination of work done, enthalpy change, and internal energy change in reversible and irreversible expansion and compression, zero, first, second law of thermodynamics and their applications, entropy and its calculations, Nernst heat theorem and third law of thermodynamics, residual entropy.	12
2	**Advanced Thermodynamics-II:** Free energy and its calculation, properties of Helmholtz free energy and Gibb's free energy, Clausius-Claypeyron equation, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and chemical potential and their significance, Gibbs-Duhem equation, Concept of fugacity and its determination, chemical potential and fugacity, thermodynamic functions of mixing.	12
3 2.	**Thermodynamics of Non-ideal Solutions:** Non-ideal systems; Excess functions for non-ideal solutions, activity, activity coefficient, Debye-Hückel theory for activity coefficient of	12

	electrolytic solutions, determination of activity coefficients, ionic strength.	
4 3.	**Chemical Dynamics-I:** Third and general order reactions, Experimental methods for kinetic studies, *viz*; conductometric, potentiometric and spectrophotometeric methods, effect of temperature on rate of reaction, Arrhenius equation. Chemical molecular dynamics: Collision theory of reaction rates, steric factor, activated complex theory, comparison of collision and activated complex theories, ionic reactions, kinetic salt effects, steady state concept, kinetic and thermodynamic control of reactions.	**12**
5 4.	**Chemical Dynamics-II:** Kinetics of gaseous reactions on solid surface, unimolecular and bimolecular surface reactions, kinetics of condensation and addition polymerization reactions, mechanism of H_2-Br_2, H_2-Cl_2 reactions, decomposition of the following compounds: acetaldehyde, ozone and H_2O_2.	**12**

Books Recommended:

i. B. R. Puri, L. R. Sharma and M. S. Pathnia, Physical Chemistry, Milestone Publisher & Distributors, New Delhi.
ii. K. L. Kapoor, Physical Chemistry. Macmillan *Publishers* India Limited.
iii. K. J. Laidler, Kinetics, Pearson Education India.

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://www.classcentral.com/course/swayam-concepts-of-thermodynamics-13015
https://onlinecourses.nptel.ac.in/noc20_me20/preview
https://www.careers360.com/university/indian-institute-of-technology-kharagpur/concepts-of-thermodynamics-certification-course
https://www.coursera.org/learn/thermodynamics-intro
https://onlinecourses.nptel.ac.in/noc22_cy14/preview
https://onlinecourses.nptel.ac.in/noc20_cy22/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in	10 marks

different activities) & Attendance	

Course prerequisites: To study this course, a student must have had Passed Degree in Bachelor of Science with Chemistry as major subject.

Semester-VII
Paper-4 (Theory) MSCHE 104
Course Title: Group Theory and Spectroscopy

Programme/Class: Bachelor (Research) in Chemistry	**Year:** Fourth	**Semester:** Seven
Paper-3 Theory Subject: Chemistry		
Course Code:	**Course Title:** Group Theory and Spectroscopy	

Course Outcomes: This paper provides detailed knowledge of applications of group theory, characterization of electromagnetic spectrum, microwave spectroscopy, energies of atomic orbitals and photoelectric effect. Upon successful completion of this course, the students will be able to describe the elements of symmetry, point groups, orthogonality theorem, character table. On completion of this course students will learn about quantization of energy, diatomic rotator, Franck Condon principle, Fluorescence, Phosphorescence and stimulated emission.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1 1.	**Symmetry and Group Theory:** Symmetry elements and symmetry operations, definitions of group and subgroup and their characteristics, relation between orders of and subgroup and their characteristics, relation between orders of a finite group and its subgroup. Conjugacy relation and classes of symmetry operations, point symmetry (or group) and its classification, Schonflies symbols, representation of group by matrices (representation for the C_n, C_{nv}, C_{nh} etc. groups to be worked out explicitly), products of symmetry operations. Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use in spectroscopy.	**20**
2 4.	**Electromagnetic spectrum**: Characterization of Electromagnetic radiation, Quantization of energy, Born Oppenheimer approximation, Lambert beer's law, Zeeman and Stark effect, Representation of spectra, Signal to Noise resolution, Factors affecting width and intensity of spectral transitions, Fourier transform spectroscopy.	**10**

3	**Microwave Spectroscopy:** Diatomic vibrating rotator, Zero point energy, Force constant and bond strength, anharmonicity, Morse potential energy diagram, P, Q, R branches, Breakdown of Born Oppenheimer approximation, Interaction of rotations and vibrations, Vibrations of polyatomic molecule. Simple applications.	15
4	**Energies of atomic orbitals:** Spin and angular vector coupling for p^7 and d^2 system. Spectra of hydrogen atom and alkali metal atoms. Franck Condon principle Photoelectric effect. Principle of PES. Ionization process. Koopman's Theorem. Spectra of simple molecules, Chemical information from ESCA. Application Enhancement of spectra. Fluorescence, Phosphorescence and stimulated emission	15

Books Recommended:

i. F.A. Cotton, Chemical Application of Group Theory, Wiley.
ii. D. C. Harris, Bertolucci, Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy, Dover Publications, New York.
iii. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House, Mumbai.
iv. Gurdeep Raj, Ajay Bhagi and Vinod Jain, Group Theory and Symmetry in Chemistry, Krishna Prakashan Media (P) Ltd., Meerut.
v. Banwell. C.N, Elainine. M. McCash Fundamentals of Molecular Spectroscopy; McGraw-Hill, 1994
vi. K. Veera Reddy, Symmetry and spectroscopy of molecules., New Age International, 1998
vii. James E Huheey, Ellen. A. Keiter, Richard. L. Keiter and Okhil. K. Medhi; Inorganic Chemistry: Principles of Structure and Reactivity; , Pearson Education, 2003
viii. W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://nptel.ac.in/courses/104/104/104104080/
https://nptel.ac.in/courses/104/101/104101094/
https://onlinecourses.nptel.ac.in/noc22_cy28/preview
https://nptel.ac.in/courses/113/106/113106069/
https://onlinecourses.nptel.ac.in/noc20_mm22/preview
https://nptel.ac.in/courses/112/106/112106223/
https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod5.pdf
https://nptel.ac.in/courses/102/103/102103044/
https://nptel.ac.in/courses/102/107/102107028/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had Passed Degree in Bachelor of Science with Chemistry as major subject.

Semester-VII, Paper-5 (Practical) MSCHE 105
Course Title: Advanced Experimental Chemistry -I

Programme/Class: Certificate Course in Introductory Chemistry	**Year:** First	**Semester:** First
		Paper-2 Practical Subject: Chemistry
Course Code:		**Course Title:** Chemical Analysis-I

Course outcomes: After completing this course, the students will be able to test the inorganic mixtures of acidic and basic radicals in the given samples. Upon completion of this course, the students will have the knowledge and skills to: understand the laboratory methods and tests related to inorganic mixture analysis including the salts of normal and rare-earth elements and insoluble salts. Also, they can understand the quantitative estimation of organic molecules. The students will be able to:

Estimate qualitatively cations and anions in samples and prepare different inorganic compounds.
Estimate quantitative estimation of percentage of hydroxyl groups, amines/ phenolic contents in organic compounds and determine of iodine and saponification values of an oil sample.
Determine of DO, COD and BOD of water samples.
Identify the different organic compounds by spectroscopic methods.
Separate and systematically identify two component organic mixture by water and bicarbonate separation.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 120

Unit	Contents	Number of Lectures
1	Laboratory hazards and safety precautions	5
2	**Inorganic Salt Analysis:** Qualitative analysis of mixtures of salts containing not more than eight radicals including: (i) Rare-earth element salts (two rare element ions) (ii) Interfering radicals (iii) Other anions, which have not been done in under graduate practical. (iv) Insolubles and simple salts	40
3	**Inorganic Compound Synthesis:** Preparation of selected inorganic compounds such as: i. $[Ni(dmg)_2]$ ii. $[Cu(NH_3)_4]SO_4.H_2O$ iii. Cis-$K[Cr(C_2O_4)_2(H_2O)_2]$ iv. $Na[Cr(NH_3)_2(SCN)_4]$ v. $[Mn(acac)_3]$ vi. $K_3[Fe(C_2O_4)_3]$ vii. Prussian Blue, Tumbull's Blue viii. $Co[NH_3)_6][Co(NO_2)_6]$ ix. Cis-$[Co(trien)(NO_2)_2]Cl.H_2O$ x. Hg $[Co(SCN)_4]$ xi. $[Co(py)_2Cl_2]$ xii. $[Ni(NH_3)_6]Cl_2$ **Or** **Quantitative estimation** of metal ions by complexometric titration, direct and / or back titration, use of masking agents.	20
4	**Organic Quantitative Analysis:** i. Determination of the percentage of number of hydroxyl groups in an organic compound by acetylation method ii. Estimation of amines/ phenols using bromate-bromide solution/ or acetylation method. iii. Determination of Iodine and Saponification values of an oil sample. iv. Determination of DO, COD and BOD of water sample.	35
5	**Spectrophotometric (UV/VIS) Estimations:** Spectroscopic estimations of Amino acids, Proteins, Carbohydrates, Cholesterol, Ascorbic acid, Aspirin and Caffeine **Or**	20

	Organic Qualitative Analysis: Separation and systematic identification of two component by (a) water separation (b) $NaHCO_3$ separation	

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance/Record	10
Viva voce and overall performance	15

Course prerequisites: Passed Degree in Bachelor of Science with Chemistry and Opted Sem-VII Theory Paper-1 &2.

Suggested equivalent online courses:

One exercise each from salt mixture analysis (acidic radicals), inorganic preparation, quantitative analysis and spectroscopic estimation of organic compounds shall be given in the examination.

Distribution of marks shall be as given below:

1. Inorganic salt analysis (Acidic and Basic radicals) 20
2. Inorganic Preparation 10
3. Quantitative Organic analysis 20
4. Spectrophotometric (UV/VIS) Estimations 10
5. Viva 15
6. Home assignment/internal assessment, lab record and attendance 25

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester lab record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 02 days (06 hours per days).***

Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, **SriDev Suman Uttarakhand University, Badshahithaul.**

Suggested Readings:

i. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
ii. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
iii. Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
iv. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
v. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
vi. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

SEMESTER VIII

Paper 1 (Theory) MSCHE 201

Course Title: Advanced Inorganic Chemistry-II

Programme/Class: Bachelor (Research) in Chemistry	**Year:** Fourth	**Semester:** Eighth
		Paper-1 Theory Subject: Chemistry
Course Code:	**Course Title:** Advanced Inorganic Chemistry II	

Course outcomes: This course will provide a deep knowledge of metal ligand bonding through MOT. Students will gain an understanding of

Sigma and pi bonding in transition metal complexes through molecular orbital energy diagrams, Reaction mechanism of octahedral complexes.

This course gives a broader theoretical picture of electronic spectra of transition metal complexes. It describes selection rules, charge transfer, Orgel and Tanabe Sugano diagrams for explaining possible electronic transitions and colour of complexes.

This course will enable students to understand the magnetic behaviour of transition metal complexes which will be helpful in adding more aspects in application part of transition metal complexes.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	**Contents**	**Number of Lectures**
1 1.	**Reaction Mechanism of Octahedral Complexes I:** Energy profile of a reaction, reactivity of metal complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage.	**15**

2 2.	**Reaction Mechanism of Octahedral Complexes II:** Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions. Complimentary and non-complimentary electron transfer reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.	15
3 3.	**Electronic Spectra of Transition Metal Complexes:** Introduction, types of transition, factors affecting band width and intensity, spectroscopic ground state terms (Russell Saunders coupling/ L-S coupling/Spin orbit coupling), determination of spectroscopic terms, atomic terms. Microstates- calculation and representation, Mullikan terms (molecular term), splitting of atomic terms in octahedral and tetrahedral field. Correlation diagram (d^1, d^2 configuration in details), Orgel diagram, (d^1 -d^{10} octahedral and tetrahedral complexes), selection rules (spin and Laporte) and their relaxation. Discussion of the electronic spectrum of d^1-d^9 octahedral and tetrahedral complexes. Inter-electronic repulsion parameters-Racah parameters (A, B, C), Nephelauxetic effect. Ground state terms symbol of transition metal complexes. Tanabe Sugano diagram (d^1 - d^9 octahedral complexes). Application of Tanabe-Sugano diagram- Calculation of B, Δ_o, β. Spin-crossover in coordination compounds. Charge transfer spectra- Introduction, types, factors affecting. spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information	30
4.	b) Electronic angular momentum in diatomic molecules (classification of states)- calculation of states	

Books Recommended:

i. F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advance Inorganic Chemistry, Sixth Edition, John Wiley & Sons, New York, 2003.
ii. J. D. Lee, Concise Inorganic Chemistry, Fifth Edition, Wiley India, 2012.
iii. Atkins, Overton, Rourke, Weller and Armstrong, Inorganic Chemistry, Oxford University Press.
iv. J. E. Huheey, E. A Keiter and R. L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, Fourth Edition, Pearson Education, 2003.
v. W. W. Porterfield, Inorganic Chemistry: A Unified Approach, Elsevier.
vi. G. Wulfsberg, Inorganic Chemistry, Viva Books.
vii. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Pearson Education.
viii. S.K. Agarwal, Keemti Lal, UGC Advanced Inorganic Chemistry

Suggested online links:

1. https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
2. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy19/
3. https://onlinecourses.nptel.ac.in/noc22_cy02/preview
4. https://nptel.ac.in/courses/104/105/104105033/
5. https://nptel.ac.in/courses/104/106/104106089/

6. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000658/M014009/ET/1456899566CHE_P3_M5_etext.pdf
7. http://ddugu.ac.in/epathshala_content1.aspx
8. https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf
9. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/07.inorganic_chemistry-ii/31.magnetic_properties_of_transition_metal_ions/et/6388_et_che__p7_m31_e-text.pdf
10. https://egyankosh.ac.in/bitstream/123456789/15794/1/Unit-7.pd
11. https://www.hhrc.ac.in/ePortal/Chemistry/IImscchem-18pche3-unit1-sv.pdf
12. http://www.du.edu.eg/upFilesCenter/sci/1596861612.pdf
13. https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf
14. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/07.inorganic_chemistry-ii/31.magnetic_properties_of_transition_metal_ions/et/6388_et_che__p7_m31_e-text.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had passed theory papers of VII semester.

SEMESTER VIII
Paper-2 (Theory) MSCHE 202

Course Title: Advanced Organic Chemistry-II

Programme/Class: Masters in Chemistry	**Year: Fourth**	**Semester:** Eighth
		Paper-2 Theory Subject: Chemistry
Course Code:	**Course Title:** Advanced Organic Chemistry II	

Course outcome: This course will provide a deep knowledge of reaction mechanism. After completion of this course, the students will be able to understand the mechanism and stereochemistry electrophilic substitution reactions and free radical reaction mechanism. This course work will give student a detailed insight of mechanism of addition to carbon-carbon and carbon-hetero multiple bonds.

Study of the name reactions and the mechanism and stereochemistry of all the mentioned reactions will enhance student's skill to understand the various important methods of synthesizing compound which are industrially important. This will not only help them to clear the competitive exams but also increase the job opportunities related to these industries.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	1. **Reaction mechanism-I:** Aliphatic Electrophilic Substitution: Biomolecular mechanisms- S_E2 and S_E1. The S_E1 mechanism, electrophilic substitution accompanied by double bonds shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity. Aliphatic Nucleophilic Substitution: The S_N^2, S_N^1, mixed S_N^1 and S_N^2, S_N^i and SET mechanisms. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. Neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system. Neighbouring group assistance in substitution reactions. Substitution reactions involving non-classical carbocations. Elimination reactions: The E2, E1 and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity-effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination	**20**
2	2. **Reaction mechanism-II:** Aromatic Nucleophilic Substitution: The $S_N Ar$, S_N^1, benzyne and S_N^i mechanism. Reactivity-effect of substrate structure leaving group and attacking nucleophile. The Von-Richter, Sommelet-Hauser and Smiles rearrangements. 3. Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ispo attack, orientation in other ring systems. Diazonium coupling.	**20**
3	**Name Reactions:** Vilsmeier reaction, Gattermann-Koch	**20**

	reaction, Sandmeyer reaction, Hunsdiecker reaction, Michael reaction. Sharpless asymmetric epoxidation, Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, Wittig reaction, Heck reaction, Still reaction, Sonogarishira, Negishi coupling, Grubbs Catalyst.	

Books Recommended:

i. Jerry March, Advanced Organic Chemistry Reactions, Mechanism and Structure, John Wiley.
ii. RT Morrison and RN Boyd Organic Chemistry, , Prentice Hall.
iii. CK Ingold, Structure and Mechanism in Organic Chemistry, Cornell University Press.
iv. SM Mukherji and SP Singh, Reaction Mechanism in Organic Chemistry, Macmillan.
v. D Nassipuri, Stereochemistry of Organic Compounds, New Age International
vi. PS Kalsi, Stereochemistry of Organic Compounds, New Age International.
vii. FA Carey and RJ Sundberg, Advanced Organic Chemistry, Plenum.
viii. Modern Organic Reactions, HO House, Benjamin.
ix. Jonathan Clayden, Nick Greeves and Stuart Warren, Organic Chemistry, Oxford Chemistry press.
x. Jagdamba Singh and LDS Yadav, Advanced Organic Chemistry, Pragati Prakashan

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://nptel.ac.in/content/storage2/courses/104103022/download/module5.pdf
https://nptel.ac.in/content/storage2/courses/104103022/download/module9.pdf
https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%208.pdf
https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%207.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had passed theory papers of VII semester.

SEMESTER VIII

Paper-3 (Theory) MSCHE 203

Course Title: Advanced Physical Chemistry-II

Programme/Class: Bachelor (Research) in Chemistry	Year: Fourth	Semester: Eighth
	Paper-3 Theory Subject: Chemistry	
Course Code:	Course Title: Advanced Physical Chemistry-II	

Course Outcomes: This paper provides detailed knowledge of surface, polymer, electro and quantum chemistry. Upon successful completion of this course, the students should be able to describe Gibb's adsorption isotherm, Freundlich and Langmuir adsorption isotherm, BET method, applications of polymers, Debye-Huckel theory, Debye-Huckel-Onsagar theory and concept of quantum chemistry.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Surface Chemistry:** Gibb's adsorption isotherm, Freundlich and Langmuir adsorption isotherms, determination of free energy of adsorption, BET theory for multilayer adsorption with derivation, determination of surface area using BET method, catalytic activity on solid surfaces, macromolecules,	**12**
2	**Polymer Chemistry:** Polymers and their general applications, classification of polymers, chain configuration of polymers, liquid crystals and their applications. Molecular mass, number and mass average molecular mass, molecular mass determination using osmometry, viscometry, diffusion and light scattering methods.	**12**
3 5.	**Advanced Electrochemistry:** Determination of activity coefficient, Debye-Huckel theory of strong electrolytes with derivation, ionic atmosphere and thickness of ionic atmosphere, Debye-Huckel-Onsagar theory, theory of conduction, Onsagar equation including mathematical deduction, overvoltage and decomposition potential.	**12**
4	**Advanced Quantum Chemistry-I:** de-Broglie concept and de-Broglie equation, physical interpretation and properties of wave functions, Linear, Laplacian, Linear-momentum and Hamiltonian operators, postulates of quantum mechanics, eigen values, eigen functions, normalization and orthogonalization, derivation of the Schrodinger's wave equation, concept of cartesian and spherical coordinates,	**12**
5	**Advanced Quantum Chemistry-II:** Schrodinger's wave equation general and detailed discussion on the applications of Schrodinger's wave equation to some model systems *viz.* particles	**12**

	in a 1D-, 3D- box, harmonic oscillator, rigid rotator and hydrogen atom.	

Books Recommended:

i. B. R. Puri, L. R. Sharma and M. S. Pathnia, Physical Chemistry, Milestone Publisher & Distributors, New Delhi.
ii. K. L. Kapoor, Physical Chemistry. Macmillan *Publishers* India Limited.
iii. K. J. Laidler,Kinetics, Pearson Education India.

Suggested online links:
https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://books.google.co.in/books/about/Basics_of_Polymer_Chemistry.html?id=ciRHDwAAQBAJ&redir_esc=y
https://www.google.co.in/books/edition/Applied_Colloid_and_Surface_Chemistry/FGyIJ1Z5Tr4C?hl=en&gbpv=1&dq=SURFACE+CHEMISTRY&printsec=frontcover

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10 marks

Course prerequisites: To study this course, a student must have had passed theory papers of VII semester.

Suggested equivalent online courses:
https://onlinecourses.nptel.ac.in/noc21_cy45/preview
https://onlinecourses.nptel.ac.in/noc21_ch48/preview
https://onlinecourses.nptel.ac.in/noc20_cy27/preview
https://onlinecourses.nptel.ac.in/noc21_cy20/preview
https://www.classcentral.com/course/swayam-chemistry-i-introduction-to-quantum-chemistry-and-molecular-spectroscopy-3981
https://www.classcentral.com/course/swayam-quantum-chemistry-of-atoms-and-molecules-19982
https://nptel.ac.in/courses/104/108/104108057/
https://nptel.ac.in/courses/115/101/115101107/
https://nptel.ac.in/courses/104/101/104101124/
https://nptel.ac.in/courses/104/105/104105128/

SEMESTER VIII
Paper-4 (Theory) MSCHE 204

Course Title: Spectroscopic Techniques-I

Programme/Class: Bachelor (Research) in Chemistry	Year: Fourth	Semester: Eighth
		Paper-4 Theory Subject: Chemistry
Course Code:	Course Title: Spectroscopic Techniques - I	

Course outcomes: This course will add on the theoretical aspects of electron spin, nuclear magnetic resonance, infrared and Raman spectroscopy along with mass spectrometry which will further help in structure elucidation of various compounds through numerical problems. This is essential for structure elucidation of known as well as novel compounds.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Nuclear Magnetic Resonance Spectroscopy:** Nuclear Spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing the chemical shift. Deshielding, spin-spin interaction, factors influencing coupling constant (J). Classification (ABX, AMX, ABC, A_2B_2 etc.), spin decoupling, basic idea about instruments, NMR studies of nuclei other than proton; ^{13}C, ^{19}F and ^{31}P. Advantages of FT NMR. Use of NMR in medical diagnostics. NOE, simplification of complex spectra by the use of Shift reagent and field strength. Nuclear Overhauser Effect (NOE). ^{13}C NMR spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne and aromatic hetero aromatic and carbonyl carbon). Coupling constants. Two-dimensional NMR spectroscopy - COSY, HETCOR, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.	25
2	**Mass Spectrometry:** Introduction, ion production-EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule, example of Mass fragmentation of class of organic compounds.	15
3	**Infrared Spectroscopy:** Instrumentation and simple handling. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the bond positions and intensities, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines and carbonyl compounds (ketones, aldehydes, esters, amides, acids anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding, solvent effect on IR of gaseous,	15

	solids and polymeric materials. Vibrations of polyatomic molecules. far IR region. Metal ligand vibrations, Normal coordinate analysis. Simple applications.	
4	**Interpretation of Organic Compounds** Problems based on spectroscopic data viz. NMR, IR, UV Spectroscopy and Mass spectrometry.	**05**

Books Recommended:

i. Pavia, Lampman, Kriz, Spectroscopy, Books/Cole; Vyvyan
ii. PS Kalsi Spectroscopy of Organic Compounds, New Age International Publishers;
iii. Silverstein, Robert M.; Webster, Francis X.; Kiemle, Spectrometric Identification of Organic Compounds, John Wiley;
iv. ML Martin, JJ Delpeach and GJ Martin, Heyden, Practical NMR Spectroscopy,
v. Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
vi. RJ Abraham, J Fischer and P Loftus, Introduction to NMR Spectroscopy, Wiley.
vii. DH Williams, I Fleming, Spectroscopic Method in Organic Chemistry: Tata MacGraw Hill.
viii. Willard Merritt, Dean, Settle, Instrumental Method of Analysis: Seventh Edition, CBS, Publication.

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: To study this course, a student must have had passed theory papers of VII semester.

Semester-VIII
Paper-5 (Practical) MSCHE 205

Course Title: Advanced Experimental Chemistry-II

Programme/Class: Bachelor (Research) in Chemistry	Year: Fourth	Semester: Eighth
		Paper-5 Practical Subject: Chemistry

Course Code:	Course Title: Advanced Experimental Chemistry-II

Course outcomes:

Upon completion of this course, the students will have the knowledge and skills to: understand the laboratory methods and tests related to organic and physical experiments. The students will able to synthesize organic compounds via two steps. Students will learn to determine the velocity constant and activation energy and they will understand the effect of temperature and concentration on the rate constant, partition coefficients etc.

Credits: 4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures: 120

Unit	Contents	Number of Lectures
1	Laboratory hazards and safety precautions	10
2	**Organic Chemistry** **(a) Multi-step preparation** (i) Photochemical reaction: Benzophenone ⟶ Benzpinnacol ⟶ Benzpinacolone (ii) Beckmann rearrangement: Benzanilide from benzene Benzene ⟶ Benzophenone ⟶ Benzophenoneoxime ⟶ Benzanilide. (iii) Benzilic acid rearrangement: Benzilic acid from benzoin Benzoin ⟶ Benzil ⟶ Benzilic acid (iv) Synthesis of hetrocylic compounds Skraup synthesis: Preparation of quinoline from aniline. Fischer indol synthsis: Preparation of 2-phenyl indole from phenylhydrazine. (v) Enzymatic synthesis Enzymatic reduction: Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S(+)ethyl-3-hydroxybetanoate and determine its optical purity. Biosynthesis of ethanol from sucrose (vi) Synthesis using microwaves (vii) Alkylation of diethyl malonate with benzyl chloride. (viii) Synthesis using phase transfer catalyst (ix) Alkylation of diethyl malonate or ethylacetoacetate with an alkyl halide. **(b) Paper Chromatography/Thin Layer Chromatography** Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose etc. By Paper chromatography, thin layer chromatography and determination of R_f values.	50
3	**Physical Chemistry:** (I) Determination of the velocity constant of acid catalyzed hydrolysis of an ester. (II) Determination of activation energy of a reaction.	40

	(iii) Determination of Frequency factor of a reaction by kinetic studies. (iv) Validity of Arrhenius equation. (v) Determination of the effect of change in temperature on rate constant of a reaction. (vi) Determination of the effect of change in concentration of the reactants on rate constant of a reaction. (vii) Determination of the effect of change in concentration of the catalyst on rate constant of a reaction. (viii) Determination of the effect of change in ionic strength on the rate constant of a reaction. (ix) Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide. (x) Flowing Clock reactions (Ref. Experiments in Physical Chemistry by Showmaker). (xi) Study of the adsorption of an acid by charcoal. (xii) Validity of Freundlich's Adsorption isotherm. (xiii) Determination of Partition Coefficients. (xiv) Determination of molecular surface energy of a liquid by Stalagmometer method. (xv) Determination of association factor of the given liquid by drop-pipette method.	

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance/Record	10
Viva voce and overall performance	15

Course prerequisites: To study this course, a student must have had opted for Bachelor (Research) in Chemistry VIII sem.

One exercise from physical chemistry and two exercise from organic chemistry (including organic synthesis and chromatography) shall be given in the examination.

Distribution of marks shall be as given below:

7.	Organic Exercise	30
8.	Physical Exercise	30
9.	Viva	15
10.	Home assignment/internal assessment, lab record and attendance	25

Note:

- *The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester lab record has to be maintained by the department/college as an official record.*
- *Less than zero mark will not be awarded.*
- *The total number of students to be examined per batch shall not be more than sixty.*
- *Duration of the practical examination shall be of 2 days (6 hours each day).*
- *Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination SriDev Suman Uttarakhand University, Badshahithaul.*

Suggested Readings:

i. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
ii. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
iii. Harris, D.C.Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
iv. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
v. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

Semester-wise Titles of Theory/Practical Papers in M.Sc. Chemistry

Purpose of the Program

The Importance of chemistry arises because so many other disciplines draw on certain chemical principles and concepts. The purpose of the postgraduate chemistry program at the university and college level is to prepare our students for all those fields where knowledge of chemistry is required including academia for careers as professionals in various industries and research institutions.

Program's Outcomes

PO 1. Students will have a firm foundation in the fundamental, advance and application of current chemical and scientific theories including those in analytical, inorganic, organic and physical chemistry.

PO 2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

PO 3. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO 4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

PO 5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.

PO 6. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

PO 7. Students will be able to function as a member of an interdisciplinary problem-solving team.

Semester-IX
Paper-1 (Theory) MSCHE 301

Course Title: Solid State Chemistry

Programme/Class: Master of Chemistry	**Year:** Fifth	**Semester:** Ninth
		Paper-1 Theory Subject: Chemistry
Course Code:		**Course Title:** Solid State Chemistry

Course outcome: This course will be helpful in understanding basics of Solid-state reactions, Crystal defects and non-stoichiometry chemistry. After completion of this course, the students will able to learn the electronic properties and band theory. This course will provide knowledge on organic solids, fullerenes and molecular devices.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Content	Number of lectures
1	**Solid State Reactions, Crystal Defects and Non-stoichiometry**: General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions, Perfect and imperfect crystals, intrinsic and extrinsic defects- point defects, line and plane defects, vacancies- Schottky defects and Frenket defects	**20**
2	**Electronic Properties and Band Theory**: Metals, insulators and semiconductors, electronic structure of solids-band theory. Band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.	**20**
3	**Organic Solids, Fullerenes, Molecular Devices:** Electrically conducting solids, organic charge transfer complexes, organic metals, new super conductors, magnetism in organic materials, fullerenes- doped, fullerenes as superconductors. Molecular rectifiers and transistors, artificial photosynthetic devices.	**20**

Books Recommended:

i. G.W. Castellan, Physical Chemistry, 4th Ed. Narosa.
ii. R.G. Mortimer, Physical Chemistry, 3 rd Ed. Elsevier: NOIDA, UP.

Semester-IX
Paper-2 (Theory) MSCHE 302

Course Title: Spectroscopic Techniques-II

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Ninth
		Paper-2 Theory Subject: Chemistry
Course Code:	**Course Title:** Spectroscopic Techniques-II	

Course outcomes: This course will provide detailed knowledge of Ultraviolet spectroscopy, Molecular dissymmetry, and Nuclear Quadrupole resonance, which will further help them in structure elucidation of various compounds through numerical problems. This is essential for structure elucidation of known as well as novel compounds

Credits: 4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures- = 60

Unit	Contents	Number of Lectures
1	**Ultraviolet and Visible Spectroscopy**: Various electronic transitions (185 to 800 nm), Lambert-Beer's Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, diens, conjugated polyenes. Fieser-Woodward rules for conjugated diens and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.	**20**
2	**Molecular Dissymmetry and Chiroptical Properties**: Linear and circularly polarized lights, circular birefringence and circular dichroism, ORD and CD curves, Cotton effects. The axial helo ketone rule, Octent diagrams, Helicity and Lowe's Rule. Application of ORD and CD to structural and stereochemical problems	**20**
3	**Nuclear Quadrupolar Resonance (NQR) Spectroscopy**: Quadrupolar moment, energy lends of a quadrupolar nuclease and effect of asymmetry parameters and energy lends. Effect of an external magnetic field, selected examples for elucidation of structural aspects of inorganic compounds using NQR spectroscopy.	**12**

Semester-IX
Paper-3 (Theory) MSCHE 303

Course Title: Pericyclic Reactions and Photochemistry

Programme/Class: Master in Chemistry	**Year: Fifth**	**Semester:** Nineth
Paper-3 Theory Subject: Chemistry		
Course Code:	**Course Title: Pericyclic Reactions and Photochemistry**	

Course Outcomes: Upon successful completion of this course, the students should be able to describe basic understanding of the sigma and pie molecular orbitals and pericyclic reactions which will further clarify their concepts in solving questions related to the same.
This paper provides detailed knowledge of Photochemistry, which will further help them in structure elucidation of various compounds.

Credit: 4	**Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Lectures- = 60	

Unit	Contents	Number of

		Lectures
1	**Pericyclic Reactions:** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions- conrotatory and disrotatory motions, 4n, 4n+2 and allyl system. Cycloadditions- antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3-dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements- suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon moieties, 3,3- and 5,5 sigmatropic rearrangements. Claisen, Cope and Aza-Cope rearrangements. Fluxional tautomerism, Ene reaction.	30
2	**Basics of Photochemistry:** Laws of photochemistry, electronically excited states-life times, Energy dissipation by radiative and non-radiative processes, Franck-Condon principle, Photochemical stages-primary and secondary processes. photo-physical reactions, Jablonskii diagram, photosensitization, quantum yield and its determination, fluorescence, phosphorescence and chemi luminiscence with suitable examples.	10
3	**Photochemistry of Organic Compounds:** Photochemistry of alkenes; cis-trans isomerization, ; photochemical additions; reactions of 1,3- and 1,4-dienes; dimerization, Norrish type I & II reactions (cyclic and acyclic); α,β-unsaturated ketones; β,γ-unsaturated ketones; cyclohexenones (conjugated, cyclohexadienones (cross conjugated & conjugated); paterno- Buchi reaction, photoreductions; photochemistry of aromatic compounds, isomerisations reactions , Dewar and prismanes in isomerization, singlet oxygen reactions, photo Fries rearrangement of ester & anilide, Barton reaction, Hoffmann- Loefller-Freytag reaction.	20

Semester-IX
Paper-4(Theory) MSCHE 304

Course Title: Chemistry of Biological System

Programme/Class: Master in Chemistry	Year: Fifth	Semester: Nineth
		Paper-4 Theory Subject: Chemistry
Course Code:	Course Title: Chemistry of Biological System	

Course outcome: This paper provides detailed knowledge of bioinorganic, bioorganic and biophysical chemistry. They will get information about the synthesis and classification, extraction, purification, uses of enzymes and coenzymes, essential and trace metals and role of metal ions in biological processes. This course will bring to light the forces and

mechanisms which are essential to sustain all the life on earth. The drug designing and the impacts of these compounds on life processes is based on the understanding of all these areas in chemistry. The research and development of novel pharmaceutical products depends on these methods. This will help the students to enter in the area of research and development in all related fields.

Credit: 4	**Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Lectures- = 60	

Unit	**Contents**	**Number of Lectures**
1	**Bioinorganic Chemistry**: Essential and non-essential elements, toxic elements (Al, Hg, Cd, Pb). Role of metal ions in biological processes: K^+, Na^+, Ca^{2+}, Mg^{2+}, Mn^{2+}, Fe^{3+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}. Ion transport through cell membrane: active transport (ionophores and ion channels) and passive transport (ion pumps: Na^+/K^+ pump). Nitrogen fixation: definition, types, mechanism, structure of nitrogenase, factors affecting nitrogen fixation. Metal complexes in transmission of energy: chlorophyll a, chlorophyll b, light dependent reaction (photosystem I & photosystem II), Haeme proteins:L definition, porphin, porphyrin, haeme groups, structure and biological functions of cytochrome P450, peroxidase, catalase, myoglobin, haemoglobin, and oxygen uptake. Metalloproteins: function of metalloproteins, electron transfer (cytochrome, rubredoxin, plastocynin), light harvesting (chlorophyll), catalyst (superoxide dismutase, carbonic anhydrase), oxygen storage and transport.	**15**
2	**Bioorganic Chemistry:** Introduction, Nomenclature and classification, extraction, purification and uses of enzymes in food drink industry and clinical therapy. Chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Proximity effects and molecular adaption. Enzyme kinetics, Michaelis-Mentien and Lineweaver-Burk plots, reversible and irreversible inhibition. Transition state theory, Fisher's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by site-directed, mutagenesis. Acid-base catalysis, covalent catalysis, strain or distortion. Example of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme, carboxypeptidase A and Nitrogenase. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzymes A, thiamine pyrophosphate, NAD^+, $NADP^+$, FMN, FAD, lipoic acid and vitamin B_{12}. Enzyme catalysed metabolic reactions.	**30**
5	**Biophysical Chemistry:** Forces involved in biopolymer interactions. Electrostatic charge and molecular expansion, hydrophobic forces, osmotic pressure, membrane equilibrium. Bioenergetics: Standard free	**15**

	energy change in biological reactions. Hydrolysis of ATP, synthesis of ATP from ADP. Coupling of ATP cleavage to endergonic processes Size, shape and molecular mass of biopolymer.	

Books Recommended:

i. P.S. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age International.
ii. L. Stryer, Biochemistry 4th Ed., W. H. Freeman & Co.
iii. S. Zubay, Biochemistry Addison-Wesley.
iv. S. J. Lippard and J. M. Berg, Principles of Bioorganic Chemistry, University Science Books.
v. I. Berteni, H.B. Gray, S.J. Lippard and J.S. Valentine, Bioinorganic Chemistry, , University Science Books.
vi. Hermann Dugs and C. Penny, Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Springer-Verlag.
vii. Trevor Palmer, Understanding Enzymes, Prentice Hall.
viii. Collins J Sucking, Enzyme Chemistry: Impact and Application, Ed. Chapman and Hall.
ix. M.I. page and A. Williams, Enzyme Mechanisms Ed., Royal Society of Chemistry.
x. N.C. Price and L. Stevens, Fundamental of Enzymology, Oxford University Press.
xi. Michael D. Trevan, Immobilized Enzymes: An Introduction and Application in Biotechnology, John Wiley.
xii. Alan Fersht. Enzyme Reaction and Mechanism, W H Freeman & Co (Sd).
xiii. A.L. Lehninger, Principles of Biochemistry, Worth Publishers.
xiv. J. M. Berg, J. L. Tymoczko and L. Stryer, Biochemistry, W.H. Freeman.
xv. H. Robert Horton, Laurence A. Moran, Raymond S. Ochs, J. David Rawan and K. Gray Scrimgeour. Principles of Biochemistry, Neil Patterson Publishers/Prentice Hall
xvi. Donald *Voet*, Charlotte W. Pratt, Judith G. *Voet,* Biochemistry, John Wiley.
xvii. E.E. Conn and P.K. Stumpf, Outlines of Biochemistry, John Wiley.
xviii. L. S. W. H. Freeman, Macromolecules: Structure and Function, Prenctice Hall.
xix. Pramod Pandey, Organic Chemistry, John Wiley.

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://onlinecourses.nptel.ac.in/noc22_cy06/preview
https://onlinecourses.nptel.ac.in/noc22_cy12/preview
https://nptel.ac.in/content/storage2/courses/104103018/pdf/mod1.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home	15

assignments/ group discussions/ oral presentations	
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: To study this course, a student must have passed theory papers of VIII semester.

Semester-IX
Paper-5 (Practical) MSCHE 305

Course Title: Advanced Experimental Chemistry -III

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Nineth
	Paper-5 Practical Subject: Chemistry	
Course Code:	**Course Title:** Advanced Experimental Chemistry -III	

Course outcomes: After completing this course, the students will be able to determine the concentrations of inorganic compounds through complexometric titration and gravimetric estimation. They can separate metal ions using paper chromatography. Physical experiments will helpful in determining order of reaction, EMF of cell, conductivity, solubility and degree of dissociation/association of electrolytes.

Credits: 4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Pre-labs**	10
2	**Inorganic Chemistry:** **Quantitative analysis** of binary mixture of metal ions involving volumetric (by complexometric titration using masking and demasking agents) and gravimetric analysis (Copper-Nickel, Copper-Zinc, Silver-Copper, Silver-Nickel, Silver-Magnesium, Copper-Magnesium). **Chromatography:** separation of cations and anions by paper/TLC/Ion Exchange chromatography	45
3	**Physical Chemistry Practical exercises** i. Determination of the order of reaction by isolation method ii. Determination of the order of reaction by half life period method iii. Determination of the order of the reaction by Integration method. iv. Determination of the entropy of activation of a reaction. v. Determination of free energy change of a reaction.	45

	vi. Determination of the equilibrium constant of a reaction. vii. Determination of pH by electrical conductivity method. viii. Hydrolysis of the salts by electrical conductivity method ix. Hydrolysis of the salts by EMF. x. Determination of the dissociation constant of a weak acid by conductivity method. xi. Determination of the equivalent conductivity of a strong electrolyte conductometrically. xii. Determination of the equivalent conductivity at infinite dilution of weak electrolyte conductometrically. xiii. Validity of Ostwald's dilution law. xiv. Determination of the degree of dissociation/ association conduct metrically. xv. Determination of solubility and solubility product of sparingly soluble salts (e.g., $PbSO_4$, $BaSO_4$) conductometrically.	

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

1.

Evaluation method	Marks
Attendance/Record	10
Viva voce and overall performance	15

Course prerequisites: To study this course, a student must have opted for Master in Chemistry IX sem.

One exercise each from inorganic quantitative exercise and one from physical exercise shall be given in the examination.

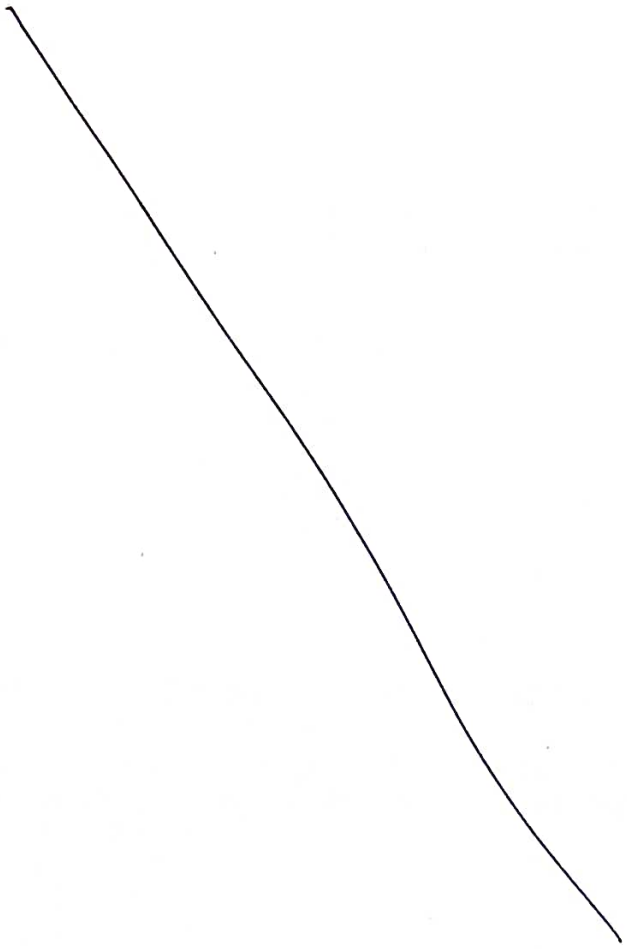
Distribution of marks shall be as given below:

1. Inorganic exercise	30
2. Physical chemistry exercise	30
3. Viva	15
4. Internal assessment	25

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***

- *The total number of students to be examined per batch shall not be more than sixty.*
- *Duration of the practical examination shall be of 2 days (06 hours each day).*
- *Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination SriDev Suman Uttarakhand University, Badshahithaul.*



Semester-X
Paper-1 (Theory) MSCCH 401
Course Title: Spectroscopic Techniques-III

Programme/Class: Master in Chemistry	Year: Fifth	Semester: Tenth
		Paper-1 Theory Subject: Chemistry
Course Code:	Course Title: Spectroscopic Techniques-III	

Course Outcomes: Upon completion of this course student will have detailed knowledge of Electron spin Resonance, Mossbauer spectroscopy, and Raman Spectroscopy. This course

will enhance student's knowledge on use of analytical techniques of above-mentioned spectroscopies which will further help them in structure elucidation of various compounds through numerical problems. This is essential for structure elucidation of known as well as novel compounds.

Unit	Contents	Number of Lectures
1	**Electron Spin Resonance Spectroscopy:** Basic Principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Hyperfine coupling isotopic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities, measurement techniques, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to inorganic and organic free radicals and to transition metal complexes (having an unpaired electron) including biological systems. Structure elucidation through problems. Structure elucidation through problems	**25**
2	**Mossbauer Spectroscopy:** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (i) bonding and structure of Fe^{+4} and Fe^{+6} compounds (ii) Sn^{+2} and Sn^{+4} compounds-nature of M-L bond, coordination number, structure and (iii) detection of oxidation state and inequivalent MB atoms. Structure elucidation through problems	**25**
3	**Raman Spectroscopy:** Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual principles. Resonance Raman spectroscopy, Coherent anti-stokes Raman Spectroscopy (CARS), Simple applications. Structure elucidation through problems.	**10**

Books Recommended:

(i) Colin N. Banwell and Elaine M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.

(ii) R. V. Parish. NMR, NQR, EPR and mössbauer spectroscopy in inorganic chemistry. Ellis Horwood, Chichester, 1990

Semester-X
Paper-II (Theory)
Course Title: Analytical Techniques MSCCH 402

Programme/Class: Master in Chemistry	Year: Fifth/	Semester: Tenth
Paper-II Theory Subject: Chemistry		

Course outcomes: This paper provides detailed knowledge of X-ray diffraction and electron diffraction techniques as well as students will learn chromatographic methods, radio analytical methods and extraction methods used in analysis of compounds. On completion of this course students will have detailed knowledge on TLC, HPLC, GLC, GSC, Ion exchange and gas chromatography.

Unit	Content	Number of Lectures
1	**X-ray Diffraction Methods:** (I) Bragg condition, Miller indices, Laue's method, Bragg's method, Debye-Scherrer method of Xray structural analysis of crystals. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules. Ramchandran diagram. (II) General Introduction of Electron Diffraction: Scattering intensity vs scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules.	12
2	**Chromatographic methods:** I. An introduction to Chromatography , Principle, instrumentation and Applications of gas and liquid chromatography, Partition Chromatography, Adsorption Chromatography , Ion Chromatography , Size-Exclusion Chromatography II. Principle and application of TLC, paper, column and HPLC, Migration Rates of Solutes, and Broadening and Column Efficiency, Optimization of Column Performance III. Principles of GLC, Instruments for GLC, Gas Chromatographic Columns and Stationary Phases, Applications of GC and advances in GC, Column Efficiency in LC, Van-Demeter equation (no derivation), concept about HEPT- plate theory and rate theory. Applications. IV. Gas-Solid Chromatography V. Ion Exchange chromatography: Cationic, anionic exchangers and their applications. VI. (vi) Gas Chromatography: Theory of gas chromatography, parts of gas chromatography, Detectors (TCD, FID, ECD).	30
3	**Radio Analytical Methods**: Basic principles and types of measuring instrument, isotope dilution techniques- principle of operations and uses. Applications. Neutron Activation Methods , Isotope Dilution Methods	10
4	**Types of Extraction**: Introduction, principle, techniques, factors affecting solvent extraction	8

Books Recommended

1. Skoog et al principles of Instrumental Analysis 2017 Brooks/ Cole Publisher
2. Vogels Analytical Chemistry. Sultan Chand & Sons publishers 2005.
3. B.K. Sharma, Instrumental methods of chemical analysis; Krishna Prakashan India 1972
4. B. R. Puri, L. R. Sharma and M. S. Pathnia, Advanced Physical Chemistry, Milestone Publisher & Distributors, New Delhi

Suggestive digital platforms web links

https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000944...
https://egyankosh.ac.in/handle/123456789/43341

Semester-X
Paper 3 (Theory Inorganic Group) MSCHEIN 403
Course Title: Inorganic Polymers

Programme/Class: Master of Chemistry	Year: Fifth	Semester: Ninth
		Paper-3 Theory Subject: Chemistry
Course Code:		Course Title: Inorganic Polymers

Course outcome: This course will be helpful in understanding basics of polymer chemistry. After completion of this course, the students will able to learn the types of polymers, their characterization, structure and properties along with different methods of polymer processing. This course will be beneficial to the students who are searching jobs in the field of polymer industry.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Content	Number of lectures
1	**Basics of Inorganic Polymers:** Importance of polymers, basic concepts: monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers, polymerization: condensation, addition, radical chain-ionic and co-ordination and co-polymerization. Polymerization conditions and polymer reactions Kinetics of polymerization. Stereochemistry and mechanism of polymerization. Polymerization in homogeneous and heterogeneous systems.	**20**
2	**Structure and Properties**: Morphology and order in crystalline polymers-configurations of polymer chains: Crystal structures of	**20**

	polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point (TM); melting points of homogeneous series, effect of chain, flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature (Tg), relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking.	
3	**Polymer Characterization:** Polydispersion, average molecular weight concept: number average, weight average and viscosity average molecular weights. Polydispersity and molecular weight distribution. Measurement of molecular weight: end-group, viscosity, light scattering, osmotic and ultacentrifugation methods. Analysis and testing of polymers, chemical analysis of polymers, spectroscopic methods, X-ray diffraction study. Microscopy. Thermal analysis and physical testing- tensile strength. Fatigue impact. Tear resistance. Hardness and abrasion resistance.	**20**

Books Suggested:

i. F.W. Bilimever Jr., Text Book of Polymer Science, Wiley.
ii. N.V. Vishwanathan and J. Sreedhar, Polymer Science, V.R. Gowarker, Willey-Eastern.
iii. K. Takemoto Y. Inaki and R.M. Ottanbrite, Functional Monomers and Polymers.
iv. H.R. Alcock and F.W. Lambe, Contemporary Polymer Chemistry, Prentice Hall.
v. J.M.G. Cowie, Physics and Chemistry of Polymers, Blakie Academic and Professional.
vi. N.H. Ray, Inorganic Polymers, Academic Press, N. York.
vii. J.M. Lehn, Supramolecular Chemistry, VCH.

Semester-X
Paper 4 (Elective Paper-Inorganic Chemistry)
(Theory) MSCHEIN 404
Course Title: General and Organometallic Chemistry

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Tenth
		Paper-4 Theory Subject: Chemistry
Course Code:	**Course Title: General and Organometallic Chemistry**	

Course Outcomes: Upon successful completion of this course, the students will be able to describe inorganic free radical reactions and chemistry of silicates and aluminosilicates. They will also able to understand the organometallic compounds of transition metals including sigma and pi bonding ligands. They will also get acquainted with the chemistry of fluxional molecules. The students will learn about chemistry and properties of some industrially important inorganic materials and their applications in various industries. It will assist them to get a suitable job in the relevant industrial and scientific field.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Organic Derivatives of Transition Metals:** Alkyls, aryls and acyls of transition metals, nature of metal carbon bond, routes of synthesis, stability, decomposition pathways, stabilization, Alkyls, aryls and acyls of s-block and p-block elements, synthesis, stability, reactivity. Comparison between transition and non-transition element derivates.	**20**
2	**Compounds of Metal-Carbon Multiple Bonds and Fluxional Organometallic Compounds:** Synthesis, properties, nature of bonding and structural features of π-bonded organo-metallic compounds (π-complexes) with unsaturated organic molecules: alkenes, alkynes, chelating olefinic ligands, allyl, dienes-butadiene, cyclobutadiene, cyclopentadiene, dienyl-cyclpentadienyl, cyclohexadienyl and arene complexes. Important reactions relating to nucleophilic and electrophilic attack on ligands, role in organic synthesis. Fluxionality and dynamic equilibria in compounds such as η^3- allyl and dienyl complexes, their characterization.	**20**
3	**Catalysis Mechanism of Some Reactions**: Stoichiometric reactions for catalysis, oxidative-addition, migratory insertion, reductive elimination, homogeneous catalytic Hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydroformylation of olefins (oxo-reaction), Wacker's process.	**20**

Books Recommended:

i. J.P. Collman, L.S. Hegsdus, J.P. Norton and R.G. Finke, Principle and Application of Organotransition Metal Chemistry, University Science Books.
ii. R.H. Crabtree, The Organometallic Chemistry of the Transition Metals, John Wiley.
iii. A.J. Person, Metallo-organic Chemistry, Wiley.
iv. R.C. Mehrotra and A. singh, Organometallic Chemistry, New Age International.
v. J.E. Huheey, E.A. Keiter, R.L. Keiter,Inorganic Chemistry: Principle of structure and Reactivity, Pearson Education.
vi. N.L.H. Green, Organometallic Compounds, Chapman & Hall, U.K.
vii. G.E. Coates, M.L.H. Green., P. Pwell,Principles of Organometallic Chemistry, Chapman & Hall, U.K.

Suggested online links:

1. https://nptel.ac.in/courses/104/101/104101079/

2. https://onlinecourses.nptel.ac.in/noc21_cy12/preview
3. https://nptel.ac.in/courses/104/108/104108062/
4. https://onlinecourses.nptel.ac.in/noc21_cy36/preview
5. https://onlinecourses.nptel.ac.in/noc22_cy05/preview
6. https://onlinecourses.nptel.ac.in/noc22_cy05/preview
7. https://nptel.ac.in/courses/104/101/104101100/
8. https://nptel.ac.in/courses/104/101/104101100/
9. https://nptel.ac.in/courses/104/101/104101079/
10. https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: To study this course, a student must have passed theory papers of IX semester.

Semester-X
Paper 5 (Elective Paper--Organic Chemistry)
(Theory) MSCHEORG 403
Course Title: Organic Synthesis

Programme/Class: Master in Chemistry	Year: Fifth	Semester: Tenth
		Paper-5 Theory Subject: Chemistry
Course Code:		Course Title: Organic Synthesis

Course outcome: Upon successful completion of this course, the students will be able to understand use of the reagents in organic synthesis. This course gives student a detailed knowledge on oxidation, reduction processes. The roadmap to synthesize important and new molecules having wide applications in the field of pharmacy, nutraceuticals, agricultural sector and luxury industries will help the students to gain a foothold in industries related to the above mentioned sectors.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Oxidation:** Introduction. Different oxidative processes. Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated & nonactivated). Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids. Amines, hydrazines and sulphides. Oxidation with ruthenium tetraoxide, iodobenzene diacetate and thallium (III) nitrate.	15
2	**Reduction:** Introduction, Different reductive process. Hydrocarbons-alkanes, alkenes, alkynes and aromatic rings. Carbonyl compounds-aldehydes, ketones, acids and their derivatives. Epoxides,Nitro, nitroso, azo and oxime groups. Hydrogenolysis.	15
3	**Disconnection Approach and Protecting Group:** An introduction to synthons and synthetic equivalents, disconnection approach, functional group interconversions, the importance of the	30

	order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, One group and two group C-C disconnections. Aliphatic nitro compounds in organic synthesis. **Protecting Group:** Principle of protection of alcohol, amine, carbonyl and carboxyl groups	

Books Recommended:

i. H.O. House, W.A. Benjamin, Modern Synthetic Reaction,
ii. W. Carruthers, Some Modern Methods of Organic Synthesis. Cambridges Univ. Press.
iii. J. March, Advanced Organic Chemistry, Reactions Mechanisms and Structure. John Wiley.
iv. R.O.C. Norman an J.M. Coxon, Principles of Organic synthesis, Blackie Academic & Professional.
v. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part B, Plenum Press.
vi. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
vii. S Warren, Designing Organic Synthesis, Wiley.
viii. J. Fuhrhop and G. Penzillin, Organic Synthesis- Concept, Methods and Starting Materials Verlage VCH.
ix. W. A. Benjamin, Modern Synthetic Reactions, H.O. House.

Suggested online links:

1. https://onlinecourses.nptel.ac.in/noc22_cy30/preview
2. https://nptel.ac.in/courses/104/105/104105087/
3. https://nptel.ac.in/courses/104/103/104103111/
4. https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEvQVRd1gUJ
5. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf
6. https://nptel.ac.in/content/storage2/courses/104103023/download/module2.pdf
7. https://nptel.ac.in/courses/104/103/104103111/
8. https://nptel.ac.in/content/storage2/courses/104103023/download/module3.pdf
9. https://nptel.ac.in/content/storage2/courses/104103022/download/module11.pdf
10. https://nptel.ac.in/content/storage2/courses/104103023/download/module4.pdf
11. https://nptel.ac.in/courses/104/105/104105087/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the	10

semester, Discipline, participation in different activities) and Attendance	

Course prerequisites: To study this course, a student must have passed theory papers of IX semester.

Semester-X
Paper 6 (Elective Paper--Organic Chemistry) MSCHEORG 404

Course Title: Chemistry of Natural Products and Heterocyclic Compounds

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Tenth
		Paper-6 Theory Subject: Chemistry
Course Code:	**Course Title: Chemistry of Natural Products and Heterocyclic Compounds**	

Course outcome: This course provides detailed knowledge of all the natural products and heterocyclic compounds such as terpenoids, alkaloids and flavonoids which form the back bone of natural system of medicine such as Ayurveda, Homeopathy, Unani system of medicine. These are upcoming areas considering the interest of all pharma companies and wellness industries as these provide sustainable approach for maintaining human health. This will provide broader areas of opportunities in these related industries.

Credits: 4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures- = 60

Unit	Contents	Number of Lectures
1	**Terpenoids, Carotenoids, Alkaloids and Steroids:** Classification, nomenclature, occurrence, isolation, general methods of structure elucidation, determination and synthesis of the following representative molecules: Menthol, Morphine and Cholesterol	**15**
2	**Plant Pigments:** Occurrence, extraction, classification, chemical characterization and functions of anthocyanins, flavonoids, xanthophylls. Chemistry and structure of cyanins, flavones, flavanol, quercetin.	**15**
3	**Heterocyclic Chemistry** **(i)Nomenclature of Heterocycles / Aromatic and Non-aromatic Heterocycles**	**30**

	Systematic nomenclature (Hantzsch-Widman System) for monocyclic, fused and bridged heterocycles. Tautomerism in aromatic heterocycles. Strain-bond angle, torsional strains and their consequences in small ring heterocycles. **(ii) Heterocyclic Synthesis/Small Ring Heterocycles** Three membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes. **(iii) Benzo-Fused Five-membered Heterocycles** Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes. **(iv) Six-Membered Heterocycles with Two or More Hetero atoms** Synthesis and reactions of pyryllium salts and pyrones. Synthesis and reactions coumarins.	

Books Recommended:

i. I. L. Finar, Vol. I & II, ELBS.
ii. Stereoselective Synthesis: A Practical Approach, M. Norgradi, VCH.
iii. Rodd's Chemistry of carbon Compounds, Ed. S. Coffey, Elsevir.
iv. Chemistry, Biological and Pharmalogical Properties of Medicinal Plants from the Americans, Ed. Kurt Hostettmann, M.P. Gupta and A. Marton, Harwood Academic Publishers.
v. Introduction to Flavonoids, B.A. Bhom, Harwood Academic Publishers.
vi. New Trends in Natural Product Chemistry, Attu-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers.
vii. Insecticides of Natural Origin, Suk Dev, Harwood Academic Publishers.
viii. Heterocyclic Chemistry Vol. 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag.
ix. Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
x. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.
xi. An Introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley.
xii. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon press.
xiii. Chemistry of Natural Products: A unified Approach, N.R. Krishnaswamy, Universities Press, Hyderabad.

Suggested online links:

https://swayam.gov.in/
https://www.coursera.org/learn/physical-chemistry
https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: To study this course, a student must have had Passed Theory Papers of VIII semester.

Semester-X
Paper-7 (Theory) MSCHEPHY 403

Course Title: Physical Organic and Quantum Chemistry

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Tenth
		Paper-7 Theory Subject: Chemistry
Course Code:	**Course Title: Physical Organic and Quantum Chemistry**	

Course outcomes: Their understanding of advanced quantum mechanics will help them to explain the related terms. Concept of molecular orbital and valence bond theories will help them to understand the bonding concept. Learning the supramolecular chemistry will help them in understanding the role of supramolecules in catalysis. They will also come to know the concept of kinetic isotopic effect. It will assist them to get a suitable job in the relevant industrial and scientific field.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Advanced Quantum Mechanics:** Applications of basic concepts of quantum chemistry, Angular momentum including spin coupling of angular momentum and spin-orbit coupling. Ordinary angular momentum, generalized angular momentum, eigen functions for angular momentum, eigen values of angular momentum, operator using ladder operators.	**20**
2	**Concepts in Molecular Orbital (MO) Theory and Concepts in Valence Bond (VB) Theory:** Introduction to Hückle Molecular	**20**

	Orbital (MO) method as means to explain modern theoretical methods, advanced techniques in PMO and FMO theory, molecular mechanics, semi empirical methods. Quantitative MO theory – Hückle Molecular Orbital (HMO) methods, qualitative MO theory-ionization potential, electron affinities, MO energy levels, orbital symmetry, orbital interaction diagrams, MO of simple organic systems. Valence Bond (VB) configuration mixing diagrams, relationship between VB configuration mixing and resonance theory, reaction profiles, potential energy diagrams, curve-crossing model nature of activation barrier in chemical reaction.	
3	**Supramolecular Chemistry I:** Molecular recognition: molecular receptors for different types of molecules including arisonic substrates, design and synthesis of co-receptor molecules and multiple recognition. Strong, weak and very weak H-bonds, utilization of H-bonds to create supramolecular structures. Use of H-bond in crystal engineering and molecular recognition. Chelate and macrocyclic effects. Cation binding hosts, binding of anions, binding of neutral molecules, binding of organic molecules. Supramolecular reactivity and catalysis. Transport processes and carrier design. Supramolecular devices, supramolecular photochemistry, supramolecular electronic ionic and switching devices. Some examples of self-assembly in supramolecular chemistry.	**20**

Books Recommended:

i. G.W. Castellan, Physical Chemistry, 4th Ed. Narosa.
ii. R.G. Mortimer, Physical Chemistry, 3rd Ed. Elsevier: NOIDA, UP.
iii. F.A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Parts A & B, Plenum: U.S.
iv. W. M. Horspool, Aspects of Organic Photochemistry, Academic Press.
v. T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry Addison-Wesley Educational Publishers, Inc.
vi. J. March, Advanced Organic Chemistry, John Wiley & Sons.
vii. L. Stryer, Biochemistry, W. H. Freeman & Co.
viii. P. A.Sykes, Guidebook to Mechanism in Organic Chemistry, Prentice-Hall.
ix. James H. Clark and Duncan J. Macquarrie, Handbook of Green Chemistry and Technology, Wiley-Blackwell.
x. Paul T. Anastas and Tracy C. Williamson Green Chemistry: Frontiers in Benign Chemical syntheses and Processes, Oxford University Press.
xi. Geoffrey Alan Ozin, A. C. Arsenault and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry.

Suggested online links:

1. https://www.ias.ac.in/article/fulltext/reso/023/03/0277-0290
2. https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
3. https://www.ias.ac.in/article/fulltext/reso/023/03/0277-0290

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: To study this course, a student must have Passed theory papers of VIII semester.

Semester-X
Paper-8 (Theory) MSCHEPHY 404

Course Title: Advanced Chemical Dynamics and Thermodynamics

Programme/Class: Master in Science	**Year: Fifth**	**Semester:** Nineth
		Paper-3 Theory Subject: Chemistry
Course Code:	**Course Title: Advanced Chemical Dynamics and Thermodynamics**	

Course outcome: This course provides advance knowledge on chemical dynamics, kinetics in solution, fast chemical reactions, statistical thermodynamics and thermodynamic equilibrium. This will inculcate the understanding of the terms and theories in detail.

Credit: 4	**Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Lectures- = 60	

Unit	**Contents**	**Number of Lectures**
I	**A. Advanced Chemical Dynamics** : Theories of reaction rates: Partition functions (translational, vibrational and rotational) for diatomic molecules and application to rate processes, statistical mechanics of chemical equilibrium, theory of absolute reaction rates, thermodynamical formulation of reactions rates, theories of unimolecular reactions: Lindemann's theory, Hinshelwood's	**16**

	treatment, RRK treatment, Slater's theory (no derivation), Rice-Ramsperger-Kassel-Marcus (RRKM) theory (no derivation), general treatment of chain reactions, branching chains, explosive reactions between hydrogen and oxygen, oxidation of hydrocarbons, polymerization reactions (molecular and free radical), oscillatory reactions, kinetic isotope effect.	
2	**Kinetics in Solution** : Influence of solvent reactions between ions, reactions between ions and molecules, reactions involving dipoles, influence of ionic strength, primary and secondary salt effects, homogeneous and heterogeneous catalysis, absolute rate theory of heterogeneous reactions. Enzyme Catalysis: Michaelis-Menton mechanism, single and double intermediates, general methods for working out the kinetics of complex enzymatic reactions.	**12**
3	**Fast Chemical Reactions:** Study of kinetics by stopped flow techniques, relaxation methods, flash photolysis and magnetic resonance methods and temperature jump method.	**10**
4	**B. Advanced Thermodynamics.** **Statistical Thermodynamics:** Introduction to Statistical Thermodynamics, Thermodynamic probability and entropy, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Partition function: Translational, rotational, vibrational and electronic partition functions for diatomic molecules, relation between partition function and various thermodynamic quantities.	**10**
5	**Thermodynamic Equilibrium:** Free energy and entropy of mixing, chemical potential and its use in heterogeneous equilibrium, fugacity, its significance and determination, Ideal solutions and their properties, Duhem-Margules equation and its applicability, Gibb's-Helmholtz equation and its uses, Nernst heat theorem, third law of thermodynamics, entropy determination from the third law of thermodynamics.	**12**

Books suggested:

i. B. R. Puri, L. R. Sharma and M. S. Pathnia, Physical Chemistry, Milestone Publisher & Distributors, New Delhi.
ii. K. L. Kapoor, Physical Chemistry. Macmillan Publishers India Limited.
iii. K. J. Laidler, Kinetics, Pearson Education India.

Suggested online links:

1. https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
2. https://www.classcentral.com/course/swayam-concepts-of-thermodynamics-13015
3. https://onlinecourses.nptel.ac.in/noc20_me20/preview
4. https://www.careers360.com/university/indian-institute-of-technology-kharagpur/concepts-of-thermodynamics-certification-course

5. https://www.coursera.org/learn/thermodynamics-intro
6. https://onlinecourses.nptel.ac.in/noc22_cy14/preview
7. https://onlinecourses.nptel.ac.in/noc20_cy22/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: To study this course, a student must have passed theory papers of VIII semester.

Semester-X,
Paper-5 (Practical) MSCHE 405

Course Title: Advanced Experimental Chemistry-IV

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Tenth
		Paper-5 Practical Subject: Chemistry
Course Code:	**Course Title:** Advanced Experimental Chemistry-IV	

Course outcomes: Upon completion of this course, the students will have the knowledge and skills to separate and identify three components in the given organic mixture. They will be able to learn the extraction of organic compounds from natural sources. Spectroscopic exercise will train them to interpret the spectral data organic compounds and will make them job ready for suitable industries. In this course, they will also perform the inorganic exercise related to semimicro analysis and preparation of various coordination compounds.

Credits:2	Compulsory
Max. Marks: 12+38	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	**Contents**	**Number of Lectures**
1	Laboratory hazards and safety precautions	**10**
2	**Organic chemistry exercise.** **1- Qualitative Analysis**	**40**

	Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid), using TLC for checking the purity of the separated compounds, chemical analysis, IR, PMR and Mass Spectral data (sets of spectra may be provided to Students for characterization of components). II- **Extraction of Organic Compounds from Natural Sources (Minimum of any two of the following exercises are compulsory)** I) Isolation of caffeine from tea leaves. II) Isolation of casein from milk (the students are required to try some typical colour reactions of proteins). III) Isolation of lactose from milk (purity of sugar should be checked by TLC, PC and Rf value reported). IV) Isolation of nicotine dipicrate from tobacco. V) Isolation of cinconine from cinchona bark. VI) Isolation of piperine from black pepper. VII) Isolation of lycopene from tomatoes. VIII) Isolation of β-carotene from carrots. IX) Isolation of oleic acid from olive oil (involving the preparation complex with urea and separation of linoleic acid). X) Isolation of eugenol from cloves. XI) Isolation of limonene from citrus fruits. III- **Spectroscopy** Identification of organic compounds by the analysis of the spectral data (UV, IR, PMR, CMR & MS)	
3	**Physical Chemistry Exercise** 1. Study of complex formation by the following methods and determination of stability constant wherever practicable: (a) Cryoscopy (b) Electrical Methods (c) E.M.F. 2. Determination of transport number. 3. Determination of liquid junction potential. 4. Determination of the charge on colloidal particle. 5. Determination of λ(max) of compounds and verification of Beer's law. 6. Validity of Langmuir's adsorption isotherm. 7. Determination of partial molar volume of solute. 8. Determination of the following thermodynamic parameters of a reaction (a) Enthalpy of activation. (b) Entropy of activation.	30

	(c) Free energy change. (d) Equilibrium constant. (e) Frequency factor 9. Conductometric determination of the equivalent conductivity at infinite dilution of a strong electrolyte. 10. Determination of the dissociation constant of a weak acid by conductivity method. 11. Conductometric determination of the equivalent conductivity at infinite dilution of a weak electrolyte. 12. Validity of Ostwald's dilution law. 13. Determination of the degree of dissociation/ association conductometrically. 14. Determination of the formula of silver ammonia complex & copper ammonia complex. 15. Kinetic Study of the primary salt effect 16. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically. 17. Determination of pH by EMF. 18. Hydrolysis of the salts by cryoscopic method. 19. Determination of strengths of halides in a mixture potentiometrically. 20. Determination of the valency of mercurous ions potentiometrically. 21. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter. 22. Verification of the law of photo-chemical equivalence.	
4	**Inorganic Chemistry Exercise** 1. Semimicro analysis of inorganic mixture for six radicals. 2. Analysis of ores, alloys and inorganic substances by qualitative and quantitative methods. **Or** Three component metal ion analysis (one volumetric and two gravimetric methods) 3. Preparation Synthesis of selected inorganic compounds/ complexes and their characterization by IR, electronic spectra (UV & Visible), NMR, Mossbauer, ESR and magnetic susceptibility etc. measurements. Selection can be made from the following or any other from the existed literature. (i) cis-and trans- isomers of $[Co(en)_2Cl_2]$ Cl. J. Chem. Soc., 1960, 4369. (ii) Metal acetylacetonates: $[Cr(acac)_3]$; Vanadyl acetylacetonate, $[Cu(acac)_2.H_2O$ etc. Inorganic Synthesis, 1957, **5**, 130; **1**, 183.	40

	(iii) Ferrocene J. Chem. Edu., 1996, **43**, 73; 1976, 53, 730. (iv) Cr(II) complexes: $[Cr(H_2O)_6](NO_3)_3 . 3H_2O$; $[Cr(H_2O)_4Cl_2]Cl.2H_2O$; $[Cr(en)_3]Cl_3$ Inorg. Synth., 1972, 13, 184. (v) Tin(IV) iodine, Tin(IV) choride, Tin(II) iodine. Inorg. Synth., 1953,4,119. (vi) Mixed valence dinuclear complexes of manganese (III, IV). (vii) Preparation of tripheny phosphine and its transition metal complexes. (viii) Reaction of Cr(III) with multidentate ligand, a kinetic experiment (visible spectra of Cr-EDTA complex). J. Am. Chem Soc., 1953,75,5670. (ix) Other new synthesis reported in literature. (x) Bromination of $[Cr(acac)_3]$. J. Chem. Edu., 1986,63,90. (xi) Preparation of copper glycine complex- cis- and trans- bis glycinato copper (II). J. Chem. Edu., 1982,59,1052. (xii) Relative stability of Tin (IV) and Pb (IV), preparation of ammonium hexachlorostannate, $(NH_4)[SnCl_6)$ and ammonium hexachoroplumbate; $(NH_4)_2[PbCl_6]$.	

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance/Record	10
Viva voce and overall performance	15

Course prerequisites: To study this course, a student must have opted Sem-VI Theory Paper-1 &2

One exercise each from inorganic analysis (quantitative), Spectroscopy/ Chromatography and physical exercise shall be given in the examination.

Distribution of marks shall be as given below:

1. Organic exercise 20
2. Physical 20
3. Inorganic 20
4. Record and Attendance 25
5. Viva 15

Note:

- *The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.*
- *Less than zero mark will not be awarded.*
- *The total number of students to be examined per batch shall not be more than sixty.*
- *Duration of the practical examination shall be of 2 days (06 hours each day).*
- *Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, SriDev Suman Uttarakhand University, Badshahithaul.*

- **Semester-X**

Semester-X
Paper-6 (Project work) MSCCH 406

Course Title: Research Project/Instrumentation/Industrial Training

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Tenth
		Paper-2 Project Subject: Chemistry
Course Code:		**Course Title: Research Project/Instrumentation/Industrial Training**

Course outcome: The students will become proficient in various analytical tools and their industrial applications.

Paper-6 (Research Project)

Course Title: Research Project/Hands on Training on Various Instruments

Programme/Class: Master in Chemistry	**Year:** Fifth	**Semester:** Tenth
		Paper-6 Research Project Subject: Chemistry
Course Code:	**Course Title:** Research Project/Hands on Training on Various Instruments	

(a)

Unit	**Contents**	**Lecture**
1	Research Project in various fields related to Chemistry. Hands on training in instruments like UV-Visible spectrophotometer, FTIR, Gas spectrometer, TGA, DSC, Spray dryer, HPLC	60

Minor/Elective courses

Semester-VII/VIII
Paper-1 (Theory) MSCHE 207 (i)
Course Title: Environmental Chemistry

Programme/Class: Master in Chemistry	Year: Fourth	Semester: Seventh/Eighth
Paper-1 Theory Subject: Chemistry		
Course Code:	Course Title: Environmental Chemistry	

Course outcomes: Upon completion of this course, the student wet the information regarding the chemical processes taking place in atmosphere, lithosphere, hydrosphere along with the chemistry of to toxic chemical and pollutants.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Introduction to Environmental Chemistry:** Concept and scope of environmental chemistry. Environmental terminology and nomenclatures. Environmental segments. The natural cycles of environment (Hydrological, Oxygen, Nitrogen).	12
2	**Atmosphere and Air Pollution:** Regions of the atmosphere, reactions in atmospheric chemistry, Earth's radiation balance, particles, ion and radicals in the atmosphere. Chemistry of ozone layer. Particulates, aerosols, SOx, NOx, COx and hydrocarbon. Photochemical smog, air-quality standards	12
3	**Hydrosphere and Water Pollution:** Complexation in natural water and waste-water. Micro-organism in aquatic chemical reactions. Eutrophication. Microbiology mediated redox reactions Water-quality parameters and standards: physical and chemical parameters (colour, odour, taste and turbidity). Dissolved oxygen: BOD, COD. Total organic carbon, nitrogen, sulfur, phosphorus and chlorine. Chemical speciation (Pb, As, Hg).	12
4	**Lithosphere:** Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil.	12
5	**Chemical Toxicology:** Toxic chemicals in the environments. Impact of toxic chemicals on enzymes. Biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, nitrogen oxides and sulphur oxides.	12

Recommended Texts:

i. Environmental Chemistry A global perspective; Fourth Edition, Gary W. vanLoon and Stephen J. Duffy
ii. Environmental Chemistry A.K. Day, New Age.

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have Passed theory papers of VIII semester.

Suggested equivalent online courses:
https://nptel.ac.in/courses/122/106/122106030/
https://nptel.ac.in/courses/104/103/104103020/
https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ce57/
https://onlinecourses.nptel.ac.in/noc21_ce63/preview
https://www.vssut.ac.in/lecture_notes/lecture1530778260.pdf
https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ

Semester-VII/VIII
Paper-2 (Theory) MSCHE 207 (ii)
Course Title: Medicinal Chemistry

Programme/Class: Master in Chemistry	Year: Fourth	Semester: Seventh/Eight
		Paper-1 Theory Subject: Chemistry

Course Code:	Course Title: Medicinal Chemistry

Course outcome: After completion of this course, the students will be able to understand the process of drug designing and to have some information about antineoplastic Agents, cardiovascular drugs, local anti-infective drugs and antibiotics and psychoactive drugs.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1	**Drug Design** : Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drug, structure-activity relationship (SAR), factors affecting bioactivity. Theories of drug activity: general discussion. Quantitative structure activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-chemical parameters: Lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials. Free-Wilson analysis, Hansch analysis, relationships between Free-Wilson and Hansch analysis. LD-50, ED-50 (Mathematical derivations of equations excluded).	**12**
2	**Pharmacokinetics & Pharmacodynamics** : Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process. Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotics, biotransformation, significance of drug metabolism in medicinal chemistry.	**12**
3	**Antineoplastic Agents:** Introduction, cancer chemotherapy, special problems, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotic and mitotic inhibitors. Synthesis of mechlorethamine, cyclophosphamide, melaphalan, uracil, mustards and 6- mercaptopurine. Recent development in cancer chemotherapy. Hormone and natural products.	**12**
4	**Cardiovascular Drugs, local anti-infective drugs and antibiotics:** Introduction, cardiovascular diseases, drug inhibitors of peripheral sympathetic function, central intervention of cardiovascular output, Direct acting arteriolar dilators, Synthesis of amyl nitrate, sorbitrate, verapamil, atenolol. **Local Anti-**	**12**

	infective Drugs and Antibiotics- Introduction and general mode of action. Synthesis of sulphonamides, furzolidone, nalidixic acid, ciprofloxacin, norfloxacin, dapsone, amino salicylic acid, isoniazid, ethionamide, ethambutal, fluconazole, econozole, griseofulvin, chloroquin and primaquin. Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis. Synthesis of penicillin G, penicillin V, ampicillin, amoxicillin, chloramphenicol, cephalosporin, tetracycline and streptomycin.	
5	**Psychoactive Drugs-The Chemotherapy of Mind :** Introduction, neurotransmitters, CNS depressants, general anaesthetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, benzodiazepines, buspirone, neurochemistry of mental diseases. Antipsychotic drugs –the neuroleptics, antidepressants, butyrophenones, serendipity and drug development, stereochemical aspects of psychotropic drugs. Synthesis of diazepam, oxazepam, clonazepam, alprazolam, phenytoin, ethosuximide, trimethadione, barbiturates, thiopental sodium, glutethimide.	**12**

Books Recommended:

i. Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH
ii. Wilson and Gisvold's Text –Book of Organic Medicinal and Pharmaceutical Chemistry, Ed. Robert F. Dorge.
iii. An introduction to Drug Design, S.S. Pandeya and U.R. Diiock, New Age International.
iv. Burger's Medicinal Chemistry and Drug Discovery, Vol.- 1 (Chapter 9 and Ch-14), Ed. M.E. Wolf, John Wiley.
v. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
vi. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
vii. Strategies for Organic Synthesis and Design, D. Lednicer, John Wiley.

Suggested online links:

https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://nptel.ac.in/courses/104/106/104106106/
https://onlinecourses.nptel.ac.in/noc20_cy16/preview
https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cy16/
https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-cy05/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral	15

presentations	
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: The students who had passed the degree of Bachelor in Science/other faculty.

Semester-VII/VIII
Paper-3 (Theory) MSCHE 207 (iii)
Course Title: Biology for Chemist
Biology for Chemist (For students of Mathematics background)

Programme/Class: Master in Chemistry	**Year:** Fourth	**Semester:** Seventh/Eight
	Paper-1 Theory Subject: Chemistry	
Course Code:	**Course Title: Biology for Chemist**	

Course outcome: The students of this course will be able to understand the functions and significance of cell organelles.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1 1.	**Cell as Unit of Life:** The cell theory; prokaryotic and eukaryotic and eukaryotic cells; cell size and shape; Eukaryotic cell components	12
2 2.	**Cell Organelles-I:** Mitochondria: Structure, marker enzymes, composition; function. Chloroplast: Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA. ER, Golgi body and Lysosomes: Structures and roles of ER, golgibody and lysosomes.	12
3 3.	**Cell Organelles-II:** Nucleus: Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief). Nucleosides and Nucleotides and DNA structure.	10
4	**Cell Membrane and Cell Wall:** The functions of membranes; Models of membrane structure; faces of the membrane, selective	12

	permeability of permeability of the membranes: cell wall	
5	**Metabolism:** Introduction, basal metabolic rate (BMR). Carbohydrate protein and lipid metabolism, cell respiration, anaerobic respiration, aerobic respiration, formation of acetal COA, citric acid cycle, electron transport system, adenosine triphosphate, mechanism. ATP generation	**14**

Books Recommended:

i. P. H.Raven, Biology, Tata MacGraw Hill.
ii. P. Sheeler, Cell and Molecular Biology, John Wiley.
iii. N. A. Campbell, Biology Pearson.
iv. L.Styer, Biochemistry, Freeman & Co.
v. Outlines of biochemistry. Fourth edition (Conn, Eric E.; Stumpf, P. K.). Wiley India Pvt. Limited

Suggested online links:

https://nptel.ac.in/courses/102/103/102103012/
https://nptel.ac.in/content/storage2/courses/102106025/Mod%201/Lec-1.pdf
https://books.google.co.in/books/about/Biology_for_Chemists.html?id=N4nToAEACAAJ&redir_esc=y

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: To study this course, a student must have had the chemistry in class 12th

SEMESTER VII/VIII

Paper-4 (Theory) MSCHE 207 (iv)

Course Title: Mathematics for Chemist (for students of biology background)

Programme/Class: Master in Chemistry	Year: Fourth	Semester: Seventh/Eight

	Paper-1 Theory Subject: Chemistry
Course Code:	**Course Title: Mathematics for Chemist**

Course outcome: The students of this course will be able to understand fundamentals of mathematical concepts.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	Contents	Number of Lectures
1 4.	**Mathematical Functions:** Polynomial expression, exponential function, trigonometrically function. inverse trigonometrically function. Logarithms and anti logarithms	10
2 5.	**Curve Sketching/Graph:** Inclination of a line and the slope of a line, General equation of straight line, slope-intercept form, slopepoint form. Two point form, Intercept form, Parallel and perpendicular lines	12
3 6.	**Differentiation:** Differentiation formulas, Concept of maximum and minimum, Rules of finding maxima and minima, Partial differentiation, Euler reciprocal relation, exact and in exact differentials, Chain rule for partial differential	14
4 7.	**Integration:** Methods of integrations, substitution, partial function, by parts, successive, reduction, integration formulas including concept of limit	10
5	**Fundamentals of Mathematical Relations**: Permutations and Combination, Probability, vectors mathematical relations, Vectors, Matrices, Determinants, Complex number, Series, Stirling approximation, Roots of quadratic equation. Methods of solving equation. Coordinate systems in three dimensions (Cartesian, spherical and polar).	14

Books Recommended:

i. D.A. McQuarrie, Mathematics for physical Chemistry University Science Books.
ii. R.Mortimer, Mathematics for Physical Chemistry, 3rd Ed. Elsevier.
iii. E. Steiner, The Chemical Maths Books, Oxford University Press.

Suggested online links:

https://www.jcu.edu.au/__data/assets/pdf_file/0004/115897/Maths-for-Chemistry.pdf
https://www.birmingham.ac.uk/Documents/college-eps/college/stem/Student-Summer-Education-Internships/Maths-for-Chemists-Booklet.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10

Course prerequisites: The students who had passed the degree of Bachelor in Science/other faculty.

Semester-VII/VIII
Paper-5 (Theory) MSCHE 207 (v)
Course Title: Inter Disciplinary Topics in Chemistry

Programme/Class: Master of Chemistry	**Year:** Fourth	**Semester:** Seventh/Eighth
		Paper-1 Theory Subject: Chemistry
Course Code: CHEM 301	**Course Title:** Inter Disciplinary Topics in Chemistry	

Course outcomes: This course will provide a broad foundation in green chemistry, medicinal chemistry, polymer chemistry, environmental chemistry that stresses scientific reasoning and analytical problem solving with a perspective. Students will gain an understanding of molecular geometries, physical and chemical properties of green reagents. This course gives a broader theoretical and practical knowledge of nano chemistry, medicinal chemistry, polymer chemistry and environmental chemistry.It describes scope of nanomaterials, chemical methods for synthesis of nanomaterials, methods of characterization. It enables to understand the Chemistry of antineoplastic agents and cardiovascular drugs. The chapter environmental chemistry gives the clear picture of terminology and nomenclature of aerosols, photo chemical smog, BOD and COD.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Lectures = 60

Unit	**Content**	**Number of lectures**
I	**Green Chemistry:** Basic principles of green chemistry. Designing green reagents: green catalyst phase transfer catalysis for green synthesis choice of starting materials, organic synthesis in solid	**12**

	phase reagents, versatile ionic liquids as Scherrer method.	
2	**Nano chemistry**: History, definition and scope of nanomaterials, chemical methods for synthesis of nanomaterials, methods of characterization, determination of particle size and surface structure by Scanning Electron microscopy, Transmission Electron microscopy, surface area analysis and Debye-Schrrer method.	**12**
3	**Medicinal Chemistry:** Primary knowledge of structure activity relationship, SAR, quantitative structure activity relationship (QSAR), Chemistry of antineoplastic agents and cardiovascular drugs.	**12**
4	**Polymer Chemistry:** Definition and importance of polymers, monomers, repeat units, degree of polymerization, condensation, addition, radical chain-ionic and co-ordination and co-polymerization, polymerization conditions and polymer reactions, general mechanism of polymerization, polymerization in homogeneous and heterogeneous systems, comparison with organic polymers.	**12**
5	**Environmental Chemistry:** Concept and scope, composition of atmosphere, terminology and nomenclature, aerosols, photo chemical smog, BOD and COD.	**12**

Books Recommended

i. Geoffrey A. Ozin, and Andre Arsentte, Neno Chemistry, RSC Publishing.

ii. A.K. Day, Environmental Chemistry New Age.

https://onlinecourses.nptel.ac.in/noc22_cy24/preview
https://drive.google.com/drive/folders/1FVY2nWBmNohhazw338xUgtEyQVRd1gUJ
https://www.vssut.ac.in/lecture_notes/lecture1530778260.pdf
https://nptel.ac.in/courses/118/102/118102003/
https://nptel.ac.in/courses/104/106/104106106/
https://nptel.ac.in/courses/104/105/104105039/
https://nptel.ac.in/content/storage2/courses/122106030/Pdfs/1_1.pdf
https://nptel.ac.in/content/storage2/courses/122101001/downloads/lec-15.pdf
https://nptel.ac.in/content/storage2/courses/103108100/module2/module2.pdf
https://nptel.ac.in/content/storage2/courses/103108100/module5/module5.pdf
https://nptel.ac.in/courses/104/105/104105034/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which

can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10

Course prerequisites: The students who had passed the degree of Bachelor in Science/other faculty.

Suggested equivalent online courses:
https://onlinecourses.nptel.ac.in/noc22_cy24/preview
https://www.ch.ic.ac.uk/marshall/4110/41101.pdf
https://nptel.ac.in/courses/118/102/118102003/
https://nptel.ac.in/courses/104/106/104106106/
https://onlinecourses.nptel.ac.in/noc20_cy16/preview
https://nptel.ac.in/courses/104/105/104105039/
https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod16.pdf
https://nptel.ac.in/courses/103/106/105106205/
https://nptel.ac.in/courses/122/106/122106030/
https://nptel.ac.in/courses/105/107/105107176/
https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ce57/