Scheme 2026

रसायन विज्ञान विभाग
राष्ट्रीय प्रौद्योगिकी संस्थान श्रीनगर

DEPARTMENT OF CHEMISTRY
NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

(शिक्षा मंत्रालय, भारत सरकार के तत्वावधान में राष्ट्रीय महत्व का एक स्वायत्त संस्थान)
(An Autonomous Institute of National Importance under the aegis of the Ministry of Education, Govt. of India)
हज़रतबल, श्रीनगर – १९०००६, जम्मू और कश्मीर, भारत Hazratbal, Srinagar – 190006, Jammu & Kashmir, India

Revised Scheme M.Sc. Chemistry (Autumn 2026) [Two Years Full Time Programme]

FIRST YEAR											
I Semester						**II Semester**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
MSCYT-101	Structure, Reactivity and Stereochemistry of Organic Molecules	2	1	0	3	MSCYT-201	Organic Reaction Mechanisms	2	1	0	3
MSCYT-102	General Inorganic Chemistry	2	1	0	3	MSCYT-202	Bio-Inorganic and Group Theory	2	1	0	3
MSCYT-103	Advanced Electrochemistry and Chemical Kinetics	2	1	0	3	MSCYT-203	Solid State Chemistry and Thermodynamics	2	1	0	3
MSCYT-104	Instrumental Methods of Chemical Analysis	2	1	0	3	MSCYT-204	Advanced Separation Techniques	2	1	0	3
Electives (Choose Any Two Out of Four)						**Electives (Choose Any Two Out of Four)**					
MSCYE-105	Supramolecular Chemistry	3	0	0	3	MSCYE-205	Biomolecules	3	0	0	3
MSCYE-106	Environmental Chemistry	3	0	0	3	MSCYE-206	Nuclear Chemistry	3	0	0	3
MSCYE-107	Tribochemistry of Lubricating Materials	3	0	0	3	MSCYE-207	Energy Conversion and Storage Systems	3	0	0	3
MSCYE-108	Polymer Science	3	0	0	3	MSCYE-208	Bioinspired Surface Engineering	3	0	0	3
Lab Courses						**Lab Courses**					
MSCYL-109	Organic Chemistry Laboratory-I	0	0	3	1	MSCYL-209	Organic Chemistry Laboratory -II	0	0	3	1
MSCYL-110	Inorganic Chemistry Laboratory-I	0	0	3	1	MSCYL-210	Inorganic Chemistry Laboratory-II	0	0	3	1
MSCYL-111	Physical Chemistry Laboratory-I	0	0	3	1	MSCYL-211	Physical Chemistry Laboratory-II	0	0	3	1
	Total Hrs./Credits	**27**			**21**		**Total Hrs./Credits**	**27**			**21**

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SECOND YEAR											
III Semester						**IV Semester**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
MSCYT-301	Organic Spectroscopy and Modern Organic Synthesis	2	1	0	3	MSCYS-401	Pre-project Seminar	0	0	0	4
MSCYT-302	Organometallic Chemistry	2	1	0	3	MSCYP-402	Project/Dissertation	0	0	0	14
MSCYT-303	Quantum Chemistry	2	1	0	3						
MSCYT-304	Advanced Characterization Techniques	2	1	0	3						
Electives (Choose Any Two Out of Four)						**Total Hrs./Credits**					**18**
MSCYE-305	Applied Organic Chemistry	3	0	0	3	**Curriculum Summary**					
MSCYE-306	Nanotechnology	3	0	0	3	Core Courses					36
MSCYE-307	Organic Flexible Electronic Materials	3	0	0	3	Elective Courses					18
MSCYE-308	Metal–Organic Frameworks: Fundamentals and Applications	3	0	0	3	Laboratory Courses					08
Lab Courses						Pre-Project Seminar					04
MSCYL-309	Analytical Chemistry Laboratory	0	0	3	1	Project/Dissertation					14
MSCYL-310	Computer Methods in Chemistry Lab	0	0	3	1						80
Total Hrs./Credits		**24**			**20**	**Total Hrs./Credits**					**80**

SEMESTER WISE CREDIT POINTS					
Semesters	Sem-I	Sem-II	Sem-III	Sem-IV	Overall
Credits	21	21	20	18	80

Autumn 2026

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Structure, Reactivity and Stereochemistry of Organic Molecules				**Mid-Term:** 26 Marks
Code: MSCYT-101	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. Javid Ahmad Banday				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the structure, reactivity and stereochemistry of organic molecules.

Course Outcomes	**CO1**	Electronic effects and concept of aromaticity.
	CO2	Involvement of reactive intermediates and understand their structure and reactivity through various organic reactions.
	CO3	Stereochemistry of organic compounds at an advanced level.
	CO4	Substitution & elimination reactions in aliphatics.

Module 1 [10L]	**Nature of Bonding in Organic Molecules** Electron Displacement effects: Inductive effect, Resonance effect, Hyperconjugation, Rules for writing resonance structures. Tautomerism: Different types including valence tautomerism. Aromaticity: Concept of aromaticity-Huckel rule, Classification of aromatic compounds-homocylcic and heterocyclic, Homo-aromaticity and Anti aromaticity. Annulenes: Aromaticity of hetero annulenes. Aromaticity in fused ring systems. Aromaticity of ferrocene and azulene. Molecular orbital diagram of annulenes.
Module 2 [10L]	**Bond Cleavage & Reaction Intermediates** Homolytic and heterolytic bond cleavage. Reactive Intermediates: Generation, Structure, fate and stability of Carbocations (Classical and Non- Classical), Carbanions, Free radicals, Carbenes, Nitrenes, Arynes and Radical ions.
Module 3 [10L]	**Stereochemistry** Conformations: Origin of conformational energy. Angle and Pitzer strain. Conformational analysis of cycloalkanes. Effect of conformation on reactivity in acyclic and cyclic systems. Conformation of sugars & anomeric effect. Conformation of cyclohexane, cyclohexanones and bicycloheptane – a bridged system. Chirality: Introduction, Chirality due to chiral centre. Molecules with more than one Chiral centers, Threo and erythro isomers. Configuration-Relative (D, L) and absolute configuration (R, S) configurations. Optical activity due to chiral axis, chiral plane and helicity. Enantiotopic and diastereotopic atoms, groups and faces.
Module 4 [10L]	**Substitution & Elimination Reactions in Aliphatic compounds** Nucleophilic Substitutions: The SN2, SN1, mixed SN1 and SN2 and SET mechanisms. The neighboring group mechanism, neighboring group participation by π and σ bonds, anchimeric assistance. The SNi mechanism. 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, regioselectivity. Elimination reactions: Factors affecting elimination reactions, Mechanism of E1, E2, E1cB and E2C reactions. Competition between substitution and elimination reactions. Stereochemistry and regioselectivity of E2 eliminations, Elimination in cyclic systems and vinyl halides. Mechanism and orientation in pyrolytic eliminations, Shapiro reaction.

Reference Books:

- Smith, M. B., March J., Advanced Organic Chemistry, 7th Ed., 2016. Wiley.
- Carey F. A., Giuliano R. M., Organic Chemistry, 8th Ed. 2012, McGraw Hill.

- Kalsi P. S., Stereochemistry of Organic Compounds, 7th Ed., 2012, New Age Inter.
- Solomons, T.W.G., Organic Chemistry, 11th Ed., 2015, Wiley.
- Carey F. A., Sundberg, R. J., Advanced Organic Chemistry Part A: Structure and Mechanisms, 5th Edition, 2007, Springer.
- Carey, F. A. and Sundberg, R. J., Advanced Organic Chemistry Part B: Reactions and Synthesis, 5th Edition, 2007, Springer.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: General Inorganic Chemistry				**Mid-Term:** 26 Marks
Code: MSCYT-102	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. Hamida Chisti/Dr. Adil Majeed				**Class-Assessment:** 24 Marks

Course Objective: The course aims at understanding the chemistry of main group, transition and inner transition elements and the detailed interception of bonding concepts, reaction mechanism in coordination compounds.

Course Outcomes	**CO1**	To learn the structure and reactivity of main group compounds.
	CO2	To learn about the chemistry and applications of Transition and Inner-transition elements.
	CO3	To learn about the theories, bonding and structure of coordination compounds.
	CO4	To learn and understand e reaction mechanisms in coordination complexes.

Module 1 [10L]	**Chemistry of Main Group Elements** General introduction to Chemical Periodicity, Structure and bonding (VBT and MOT) in homo and hetero nuclear molecules -H_2, O_2, N_2, F_2, and NO, CO, HCl. Molecular shape and the VSEPR model: Effect of Lone pairs, Effect of electronegativity, isoelectronic principle (e.g., NH_3, BF_3, $[BF_4]^-$, PCl_5, SF_4, I_3^-, SF_6, IF_7. Synthesis, Properties, Structure and Bonding of: Nitrogen, Phosphorous, Sulfur,Pseudohalogen, Interhalogen and Xenon Compounds.
Module 2 [10L]	**Chemistry of Transition & Inner Transition Elements** Transition elements: Introduction, Oxidation state, Size, Chemical properties and Complexes of Group 3- Group12 elements. Inner transition elements: Introduction, Characteristics, Extraction, Lanthanide Contraction, energetics, binary compounds, coordination chemistry, General Principles, Coordination numbers in lanthanide and actinide complexes, electronic and magnetic properties, Electronic Spectra, Luminescence Spectra.
Module 3 [10L]	**Coordination Chemistry-I** Theories of electronic Structure: Terminology and Historical background of VBT and CFT. Ligand Field Theory: Molecular Orbitals for octahedral complexes, Orbital splitting and electron spin, ligand Field stabilization energy, pi bonding, squareplaner complexes, tetrahedral complexes. Angular overlap: Sigma-donor interactions, pi acceptor interactions, pi donor interactions, types of ligands and the spectrochemical series. The Jahn Teller effect: octahedral and tetrahedral Complexes. Electronic Spectra of coordination compounds: selection rules, Correlation diagrams (Orgel Diagrams), Tanabe Sugano Diagrams
Module 4 [10L]	**Coordination Chemistry-II** Substitution reactions: Inert and Labile Compounds, Mechanisms of substitution. Kinetic consequences of reaction pathways: Dissociation, interchange and Association. Experimental evidence in octahedral substitution: Dissociation, Linear free energy relationships, associative mechanisms, the conjugate base mechanism, the kinetic chelate effect. Stereochemistry of reactions: substitution in trans complexes, substitution in Cis-complexes, Isomerization of chelate rings. Substitution reactions in square planar complexes. Evidence for Associative reactions. Trans effect: Explanations of trans effect. Oxidation reduction reactions: inner and outer sphere reactions, conditions for high and low oxidation numbers.

Reference Books:

- Huheey J. E., Inorganic Chemistry, 4th Edn., 2008, Pearson
- Miessler G. L., Tarr D.A., Inorganic Chemistry, 3rd Edn., 2008, Pearson.
- Cotton F. A., Wilkinson G., Murillo C. A., Bochmann M., Advanced Inorganic Chemistry, 6th Edn., 1999, Wiley.
- Weller and Armstrong, Inorganic Chemistry, 6th Edn., 2015, Oxford.
- Lee J. D., Concise Inorganic Chemistry, 5th Edn., 1999, Wiley,
- Atkins and Shriver, Inorganic Chemistry, 5th Edn., 2009.

Subject: Advanced Electrochemistry & Chemical Kinetics				**Mid-Term:** 26 Marks
Code: MSCYT-103	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. Kowsar Majid				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the electrochemistry and chemical kinetics.

Course Outcomes	**CO1**	To understand the structure, thermodynamics, and kinetics of electrified interfaces and electron transfer processes in electrochemical systems.
	CO2	To Understand bio- and photoelectrochemical systems for energy conversion and synthesis.
	CO3	To Analyze reaction kinetics using microkinetic approaches, fast reaction techniques, and classical and modern theories of chemical reaction rates.
	CO4	To Understand and analyze surface, solution, ionic, and catalytic reaction mechanisms, including enzyme kinetics and factors affecting reaction rates.
Module 1 [10L]		**Electrochemical Interfaces and Electron Transfer Systems** Metal–electrolyte electrified interfaces: structure and basic thermodynamics. Concept of surface excess and Lippmann equation. Electrocapillary curves and methods for determination of surface excess. Electrical double layer models: Helmholtz–Perrin, Gouy–Chapman, and Stern models with comparison. Semiconductor–electrolyte interface: structure and band theory basics. Heterogeneous electron transfer: fundamentals of electrode kinetics. Butler–Volmer equation, low and high field approximations, and significance of transfer coefficient. Introduction to Marcus theory of charge transfer and its relation to electrochemical kinetics.
Module 2 [10L]		**Bio and Photo-electrochemistry** Electrochemistry of redox enzymes: direct and mediated electron transfer, enzyme-modified electrodes, and their applications and challenges. Bioelectrosynthesis: basic mechanisms and selected examples such as alcohol oxidation, sugar transformations, reduction of carbonyl compounds, and hydrogenation processes. Solar energy conversion: principles of photoelectrochemical systems and energetics of charge transfer. Photoelectrochemistry: water splitting, CO_2 reduction, and N_2 reduction using semiconductor-based systems.
Module 3 [10L]		**Chemical Kinetics and Reaction Dynamics** Microkinetic analysis of reaction rates and order determination. Fast reactions: general features and experimental methods including flow technique, relaxation method, and flash photolysis. Theories of chemical reactions: collision theory and its limitations, Arrhenius theory, potential energy surfaces, and activated complex (transition state) theory with statistical and thermodynamic formulations; comparison of collision theory with activated complex theory. Unimolecular reaction theories: Lindemann–Hinshelwood mechanism and RRK theory.
Module 4 [10L]		**Surface, Solution Kinetics & Catalysis** Surface reactions: unimolecular and bimolecular surface processes; Langmuir–Hinshelwood and Langmuir–Rideal mechanisms; classical and statistical treatments of surface reactions. Reactions in liquid solutions: diffusion-controlled reactions (partial and full microscopic diffusion control). Ionic reactions: single-sphere and double-sphere models, and effect of ionic strength.

	Catalysis: Introduction and general mechanisms of catalysis; role of solvents as catalysts. Enzyme catalysis: Michaelis–Menten equation, enzyme inhibition, and effects of pH and temperature on enzymatic reaction rates.

Reference Books:

- Modern Electrochemistry, Vol. 1 & 2A: Fundamentals of Electrodics; Author(s): John O'M. Bockris, Amulya K. N. Reddy, Maria Gamboa-Aldeco ; Edition: 2nd Edition ; Publisher: Springer (formerly Plenum Press);Year: 1998–2000
- Electrochemical Methods: Fundamentals and Applications; Author(s): Allen J. Bard, Larry R. Faulkner ; Edition: 2nd Edition; Publisher: John Wiley & Sons; Year: 2001
- Chemical Kinetics; Author: Keith J. Laidler ; Edition: 3rd Edition ; Publisher: Pearson Education
- Kinetics of Catalytic Reactions; Author: *M*. Albert Vannice ;Edition: 1st Edition (2005); Publisher: *Springer*
- Modern Electrochemistry: An Introduction to an Interdisciplinary Area; Author(s): *John O'M. Bockris, Amulya K. N. Reddy ;* Edition: *1st Edition*;Publisher: *Plenum Press ;*Year: *1970*
- *Physical Chemistry of Surfaces;* Author: Arthur W. Adamson ;Edition: 6th Edition; Publisher: Wiley ;Year: 1997
- Interfacial Electrochemistry: An Experimental Approach; Author(s): *Andrzej J. Bard, Alan T. Hubbard* Publisher: Wiley/Academic Press

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Instrumental Methods of Chemical Analysis				**Mid-Term:** 26 Marks
Code: MSCYT-104	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Dr Mohammad Aslam				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the analysis of experimental data and learn various analytical techniques used that would be applied in all areas of research, various industries and quality assurance labs.

Course Outcome	
CO1	Data handling and statistical treatment of data.
CO2	Thermal methods and their applications to material science/chemical science.
CO3	Electroanalytical techniques like cyclic voltammetry and polarography.
CO4	X-ray methods of analysis and their application to material science/chemical science.

Module 1 [10L]	**Statistics and Data Analysis** Errors, classification of errors and their minimization; absolute, relative, determinate and indeterminate errors, statistical treatment of random errors, accuracy and precision, methods of expressing accuracy and precision, mean, mode, median, and standard deviation, relative standard deviation, variance test, statistical treatments of data; hypothesis/significance tests, the F test, the t test, Q test, analysis of variance (ANOVA) calculations and problems.
Module 2 [10L]	**Thermal Methods** Introduction to thermal methods, classification of thermal methods. Thermogravimetric analysis, principle, interpretation of TGA thermograms, instrumentation, working and applications. Derivative thermogravimetry, principle, instrumentation, working and applications. Differential thermal analysis, principle, instrumentation, working and applications. Differential scanning calorimetry, principle, instrumentation, working and applications. Comparative study of TGA, DTA and DSC. Interpretation of various thermograms of important compounds; silver nitrate, calcium oxalate monohydrate, magnesium oxalate dihydrate and the purity analysis of dolomite and calcite minerals using thermogravimetric analysis.
Module 3 [10L]	**Electro-analytical Methods** Introduction to electroanalytical methods and its classification, principle of voltammetry, types of voltammetry, voltammetry instrumentation, reference, working and auxiliary electrodes, voltammogram, working and instrumentation. Hydrodynamic voltammetry, principle, instrumentation working and applications. Cyclic voltammetry, anodic and cathodic peak currents, anodic and cathodic peak potential, Randles–Sevcik equation, cyclic voltammograms of K3[Fe(CN)6], applications of cyclic voltammetry. Polarography; principle, instrumentation, dropping mercury electrode (DME), residual, diffusion and limiting currents, half-wave potential, Ilkovic equation, applications.
Module 4 [10L]	**X-ray Methods** Introduction to X-ray methods, generation of X-rays, X-ray Diffraction; principle, theory, instrumentation, chemical analysis with X-ray diffraction and applications. X-Ray photoelectron spectroscopy (XPS/ESCA); principle, chemical shifts as a function of oxidation states, instrumentation, applications; Auger electron spectroscopy (AES); principle, instrumentation-radiation source, energy analyzer, detector, auxiliary system; applications.

Reference Books:

- Christian G. D., Dasgupta P. K., Schug K. A., *Analytical Chemistry*, Willey Publisher, 2020.

- Skoog D., Holler F., Crouch S., *Principles of Instrumental Analysis*, 7th Edition, Brooks/Cole Publishers, 2017.
- Willard, Merritt, Dean, Settle, *Instrumental Methods of Analysis*, 7th Edition, CBS Publisher, 1986.
- Harvey D., *Modern Analytical Chemistry*, McGraw Hill Education, New York, 2000.
- Skoog D. A., Donald M. W., Holler F. J., Crouch S.R., *Fundamentals of Analytical Chemistry*, 9th Edition, Brooks/Cole Publishers, 2014.
- Settle F.A., *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, 1997.
- Leng Y., *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Wiley & Sons, 2008.
- Goldstein J., Newbury D.E., Joy D.C., Lyman C. E., *Scanning Electron Microscopy and X-Ray Microanalysis*, 3rd Edition, Springer, 2013.
- Kaur H., *Instrumental Methods of Chemical Analysis,* 2012, Pragati Prakashan, Meerut, 2012.
- Chatwal G.R., Anand S. K., *Instrumental Methods of Chemical Analysis*, 5th Edition, Himalya Publishing House, New Delhi, 2019.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Supramolecular Chemistry				**Mid-Term:** 26 Marks
Code: MSCYE-105	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Dr. Ravi Kumar				**Class-Assessment:** 24 Marks

Course Objective: The course provides a fundamental overview of supramolecular chemistry, highlighting its role as a versatile tool for constructing complex systems from well-defined units and exploring their applications in diverse areas of research and technology.

Course Outcome	**CO1**	To understand the fundamentals of supramolecular chemistry, including molecular recognition and host–guest interactions in supramolecular systems.
	CO2	To understand the supramolecular reactivity and to evaluate the applications of supramolecular systems in catalysis, sensing and device development.
Module 1 [15L]		**Fundamentals of Supramolecular Chemistry and Molecular Recognition** Terminology and definitions in supramolecular chemistry. Intermolecular forces: Ion pairing, ion-dipole and dipole-dipole interactions; hydrogen bonding; cation-pi, anion pi, pi-pi interactions and Vander Waal forces. Solvation and hydrophobic effects. Host-guest complementarity, pre-organization, chelate effect and cooperativity. Synthesis and applications of supramolecular host (Crown ethers, Porphyrin and other Tetrapyrrolic Macrocycles, cryptands, cyclodextrins) as cation and anion binding receptors and receptors for ion-pair recognition.
Module 2 [15L]		**Supramolecular Catalysis and Supramolecular Devices** Organocatalysis mediated through hydrogen bonding, preconcentration, self-assembly of catalysts and preorganisation of catalyst-substrate systems. Influence of organization (effective molarity) on catalysis, catalytic acyl transfer. Supramolecular Sensors and Devices –Thermochromism and Solvatochromism, Charge Transfer Complexes, theory of π- π stacking, Organic Light Emitting Diodes (OLEDs), transistors and organic lasers (elementary idea).

Reference Books:

- Lehn, J.-M., *Supramolecular chemistry: Concepts and perspectives*. Weinheim, Germany: Wiley-VCH., 1995.
- Schneider, H.-J., & Yatsimirsky, A., *Principles and methods in supramolecular chemistry*. Chichester, UK: Wiley, 2000.
- Sessler, J. L., Gale, P. A., & Cho, W.-S., *Anion receptor chemistry*. Cambridge, UK: Royal Society of Chemistry, 2006.
- Steed, J. W., & Atwood, J. L., *Supramolecular chemistry* (3rd ed.). Wiley, 2022.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Environmental Chemistry				**Mid-Term:** 26 Marks
Code: MSCYE-106	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. S. A. Shah				**Class-Assessment:** 24 Marks

Course Objective: To introduce the concepts of Environmental Chemistry, various aspects of the four main spheres of earth: Atmosphere, Biosphere, Hydrosphere and Lithosphere, their interactions amongst each other and their influence on humanbeings

Course Outcomes	**CO1**	Familiarize the basics of Environmental chemistry and its numerous facets
	CO2	To understand the analysis and its treatment methods
Module 1 [15L]		**Environment: Atmosphere, Water and Soil** Structure, chemical composition and distribution elements, biological cycles, biodistribution of elements. Reactions in atmosphere involving oxides of N, S and C. Air pollution and air quality standards- Green House effect, Global Warming, climate change, Photochemical smog, Ozone formation and Depletion, Acid rains. Water Pollution: Water quality criteria for domestic and industrial use, BIS and WHO standards, ground water and surface water pollution-Rivers, lakes and marine water pollution by detergents, pesticides and microplastics Soil inorganic and organic components, micro and macro nutrients, Solid waste and pollutants in soil
Module 2 [15L]		**Analysis and Treatment Methods** Water analysis parameters-colour, odour, conductivity, TDS, pH, acidity, alkalinity, chloride and residual chlorine, hardness, nitrates, sulphates, phosphates, BOD, COD, DO- their significance and determination. Treatment of water for drinking purposes- Sedimentation, chlorination, Lime-Soda process. Waste water treatment and management. Water treatment for industrial use. Solid waste management, treatment and recycling, soil analysis, radioactive pollution and disposal. Sampling, monitoring atmospheric water and soil pollution

Reference Books:

- Environmental chemistry; A. K. De ; Wilay Eastern; 1995.
- Environmental chemistry; S. E. Manahan; Lewis Publishers; 2000
- Environmental Sciences; Dr. R.J. Chhatwal; 2nd Revised Edition 2011.
- Environmental Pollution analysis; S. M. Khopkar; Wiley Eastern.
- Environmental Chemistry, L. W. Moore and E. A. Moore McGraw Hill Publication, New York, 2002

Subject: Tribochemistry of Lubricating Materials				**Mid-Term:** 26 Marks
Code: MSCYE-107	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Kowsar Majid				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the tribochemistry of various lubricating materials, their reaction mechanism and related surface chemistry.

Course Outcome	**CO1**	Explain the fundamentals of tribology, tribochemistry, friction, wear, and lubrication mechanisms
	CO2	Analyze tribochemical interactions of oil additives, nanoparticle additives, and synthetic lubricants with engineering surfaces
Module 1 [15L]		**Fundamentals and Lubricant Additives in Tribochemistry** Introduction to tribology and tribochemistry ;Friction, wear, and lubrication mechanisms Chemical interactions at contacting and sliding surfaces ;Types, properties, requirements, and specifications of lubricants ;Lubricant additives: classification and functions ;Tribochemistry of oil additives and additive–surface interactions; Anti-wear, extreme-pressure, and friction-modifying additives; Synthetic engine oils: composition, properties, and applications; Tribochemistry of nanoparticle additives; Rare-earth-based lubricant materials and their tribological behavior
Module 2 [15L]		**Advanced Lubricating Materials and Surface Engineering** Ionic liquids: structure, properties, and tribological applications ;Tribochemistry of ceramic materials ;Diamond-like carbon (DLC) films: structure, properties, and applications ;Molecular structure and tribology of organic thin films ;Surface film formation and protective tribochemical layers ;Tribochemistry of polymers and polymer-based lubricants ;Friction, wear, and transfer film formation in polymers ;Emerging trends and industrial applications of advanced lubricating materials

Reference Books:

- Engineering Tribology, 4th Edition, Elsevier Butterworth–Heinemann, 2014.
- Tribology: Friction and Wear of Engineering Materials, 2nd Edition, Butterworth–Heinemann (Elsevier), 2017.
- Lubrication Fundamentals, 3rd Edition, CRC Press, 2016. Don M Pirro, Martin Webster, Ekkehard Daschner
- Introduction to Tribology, 2nd Edition, John Wiley & Sons, 2013. Bharat Bhushan
- Modern Tribology Handbook, 2 Volume Set, CRC Press, 2000.
- Nanotribology and Nanomechanics, 4th Edition, Springer, 2017.
- Ionic Liquids as Green Lubricants, Springer, 2013

<table>
<tr><td colspan="5">Subject: Polymer Science</td><td>Mid-Term: 26 Marks</td></tr>
<tr><td colspan="2">Code: MSCYE-108</td><td>Credits: 3</td><td>L [3] : T [0] : P [0]</td><td>Hours: 30</td><td>End-Term: 50 Marks</td></tr>
<tr><td colspan="5">Teacher In charge: Dr. Adil Majeed Rather</td><td>Class-Assessment: 24 Marks</td></tr>
<tr><td colspan="6">Course Objective: To provide students with a comprehensive understanding of polymer science, synthesis, and processing, along with advanced fabrication techniques and emerging applications of polymeric materials in industrial, biomedical, environmental, and sustainable engineering technologies</td></tr>
<tr><td rowspan="2">Course Outcome</td><td>CO1</td><td colspan="4">Understand the fundamentals, synthesis, and fabrication techniques of polymeric materials used in modern engineering applications.</td></tr>
<tr><td>CO2</td><td colspan="4">Analyze the industrial, biomedical, environmental, and advanced functional applications of polymers, including sustainable and stimuli-responsive polymeric systems.</td></tr>
<tr><td colspan="2">Module 1 [15L]</td><td colspan="4">Fundamentals, Properties, and Fabrication of Polymers
Introduction to polymer science, classification of polymers, thermoplastics, thermosetting polymers and elastomers, glass transition temperature, crystallinity, and mechanical, thermal, optical, and electrical properties of polymers. Biodegradable, conducting, and smart polymers. Polymerization techniques including addition, condensation, free radical, emulsion, and copolymerization. Preparation of polymer composites, nanocomposites, fibers, films, and porous polymeric materials.</td></tr>
<tr><td colspan="2">Module 2 [15L]</td><td colspan="4">Applications and Emerging Trends in Polymeric Materials
Applications of polymers in packaging, coatings, adhesives, textiles, automotive industries, biomedical engineering, drug delivery, tissue engineering, wound dressing, flexible electronics, sensors, membranes for water purification and oil–water separation. Advanced functional materials, including self-healing, stimuli-responsive, and sustainable polymers, along with polymer recycling technologies and environmental challenges associated with plastics.</td></tr>
<tr><td colspan="6">Reference Books:
• Gowariker. V. R, Viswanathan. N. V, and Sreedhar J, Polymer Science, New Age International Publishers, 1986
• Stevens. M. P, Polymer Chemistry: An Introduction, Oxford University Press, 1999.
• Billmeyer. F. W, Textbook of Polymer Science, Wiley-Interscience, 1984.
• Carraher Jr. C. E, Introduction to Polymer Chemistry, CRC Press, 2017.</td></tr>
</table>

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Organic Chemistry Laboratory – I				**Continuous Assessment:** 60 Marks
Code: MSCYL-109	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher In charge: Prof. Tabassum Ara				

Course Objective: The course has been designed to enable the students to learn the organic chemistry practical skills.

Course Outcome	
CO1	Purification techniques.
CO2	Separation and purification of organic compounds
CO3	Separation of a binary mixture of organic compounds
CO4	Qualitative analysis of organic compounds

Exp. 1	**Purification techniques (Demonstrations)** Purification of solvents and reagents using Techniques like crystallization, sublimation, fractional distillation, vacuum distillation, drying and storage of solvents.
Exp. 2-4	**Separation and Purification** Separation and Purification of organic compounds using thin layer chromatography and column chromatography. (Two exercises).
Exp. 5-7	**Separation of a binary mixture** Separation of a binary mixture of organic compounds based on solubility in water and organic solvents. (Two exercises)
Exp. 8-10	**Identification of the organic compounds** Identification of the organic compounds by systematic qualitative organic analysis (Two exercises).

Reference Books:

- Vishnoi N.K., Advanced Practical Organic Chemistry, 2nd ed. 1999, Vikas
- Pasto D., Johnson C., Miller M., Experiments and Techniques in Organic Chemistry, 1992, Prentice-hall

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Inorganic Chemistry Laboratory – I				**Continuous Assessment:** 60 Marks
Code: MSCYL-110	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher In charge: Prof. S. A. Shah/Prof. Hamida Chisti/Dr. Adil Majeed				
Course Objective: To gain practical knowledge of inorganic chemistry				

Course Outcomes	**CO1**	Synthesis of Inorganic complexes.
	CO2	Structure elucidation of the complexes.
	CO3	Percentage of ions by titration methods.
	CO4	Complexometric titration.

Exp. 1	Synthesis of tris(acetylacetonato)manganese(III),$[Mn(C_5H_7O_2)_3]$. Calculate the percentage yield and give the structure of the complex. Also write the chemical reactions involved.
Exp. 2	Synthesis of Copper(I) tetraiodomercurate (II), $Cu_2[HgI_4]$. Calculate the percentage yield and give the structure of the complex. Also write the chemical reactions involved.
Exp. 3	Synthesis of pentaaminechlorocobalt(III)chloride,$[Co(NH_3)_5]Cl_2$.Calculate the percentage yield and give the structure of the complex. Also, write the chemical reactions involved.
Exp. 4	Synthesis of nitropentaammine cobalt(III) chloride, [Co(NH3)5NO2]Cl2. Calculate the percentage yield and give the structure of the complex. Also write the chemical reactions involved.
Exp. 5	Synthesis of Sodium trioxalato ferrate trihydrate. Calculate the percentage yield and give the structure of the complex. Also, write the chemical reactions involved.
Exp. 6	Synthesis of Mohr's Salt (Ferrous Ammonium Sulphate). Calculate the percentage yield and give the structure of the complex. Also, write the chemical reactions involved.
Exp. 7	Synthesis of Reinecke's salt (Ammonium Tetrathiocyanate diamine chromate). Calculate the percentage yield and give the structure of the complex. Also, write the chemical reactions involved.
Exp. 8	Synthesis of Hexaamine Nickel-II chloride. Calculate the percentage yield and give the structure of the complex. Also, write the chemical reactions involved.
Exp. 9	To estimate the percentage of copper ions in a given solution by the titration method.

Reference Books:

- Vogel A. I., Qualitative Inorganic Analysis, 6th Edition, Revised, G. Svehla ELB– London.
- Vogel A. I., Textbook of Chemistry Analysis.
- Raj G., Advanced Practical Inorganic Chemistry, Goel Publishing House, Meerut.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Physical Chemistry Laboratory – I				**Continuous Assessment:** 60 Marks
Code: MSCYL-111	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher In charge: Dr. Shrikant Shivaji Maktedar				
Course Objective: The laboratory course has been designed to enable the students to learn the concepts in physical chemistry through practical sessions				

Course Outcome	**CO1**	To learn the principal & concepts of conductometric technique
	CO2	To learn the principal & concepts of potentiometric technique
	CO3	To learn and validate the concepts in chemical kinetics & surface chemistry
	CO4	To learn and understand the concept of viscosity & thermodynamics

Exp. 1	To titrate conductometrically the given solution of hydrochloric acid against standard sodium hydroxide solution and determine the strength and amount of the acid solution
Exp. 2	To determine concentration of KCl solution by titrating it with standard $AgNO_3$ solution using conductometry
Exp. 3	To titrate conductometrically the given solution of acetic acid against standard sodium hydroxide solution and determine the strength and amount of acid
Exp. 4	To investigate the titration of mixture of HCl and oxalic acid by NaOH using conductometric technique
Exp. 5	Titrate ferrous ammonium sulphate with cerric sulphate and hence find out formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} system
Exp. 6	To study the adsorption of acetic acid on charcoal and prove the validity of Freundlich's adsorption isotherm
Exp. 7	Determine the velocity constant of a second order reaction between potassium iodide and potassium persulphate
Exp. 8	To study the effect of acid strength on hydrolysis of methyl acetate using HCl and H_2SO_4
Exp. 9	To study the distribution of benzoic acid between water and toluene
Exp. 10	Determine the viscosity of a given liquid by Ostwald's Viscometer

Reference Books:

- Wilson J.M., Newcombe K.J., Denko A.R., Richett R.M.W., Experiments in Physical Chemistry, Pergamon Press
- Findary A., Kitchner T.A., Practical Physical Chemistry, Longmans, Green and Co.
- Khosla B.D., Garg V.S., Senior Practical Physical Chemistry, R. Chand and Co., Delhi.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Organic Reaction Mechanisms				**Mid-Term:** 26 Marks
Code: MSCYT-201	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Dr. Ravi Kumar				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the various types of reactions and rearrangements in organic molecules.

Course Outcome	**CO1**	To understand the reaction mechanisms involved in organic chemistry.
	CO2	To explore advanced organic synthesis involving additions to multiple bonds.
	CO3	To examine molecular rearrangements of synthetic importance in organic reactions.
	CO4	To analyze orbital interactions and their role in concerted reactions.

Module 1 [10L]	**Substitution Reactions in Aromatic Compounds** Electrophilic Substitutions: The arenium ion mechanism, orientation and reactivity, ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction. Nucleophilic Substitutions: The SNAr, SN1, benzyne and SRN1 mechanisms. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser and Smiles rearrangements
Module 2 [10L]	**Addition to Multiple Bonds** Addition to carbon-carbon multiple bonds: General mechanism, reactivity, orientation and stereochemical implications of additions reactions involving electrophiles, nucleophiles and free radicals. Addition to cyclopropane ring. Hydrogenation of double/triple bonds and aromatic rings. Hydroboration. Addition to carbon-hetero atom double bonds: Mechanisms of addition of water, hydrogen cyanide, alcohols, amines, organometallic reagents and hydrides to aldehydes and ketones. Mechanism of Wittig, Mannich, Aldol, Cross Aldol, Cannizarro's, Knoevenagel, Robinson annulation, Claisen, Dickma, Benzoin, Perkin and Stobbes reactions
Module 3 [10L]	**Molecular Rearrangements** General mechanistic treatment of nucleophilic, electrophilic and free radical rearrangements. Nature of migration and migratory aptitude and memory effect. Detailed study of following rearrangements: Wagner-Meerwein, Pinacol-Pinacolone, Demyanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert, Neber, Hofmann, Curtius, Lossen, Schmidt, Beckmann, Baeyer-Villiger oxidation
Module 4 [10L]	**Pericyclic Reactions** Molecular orbital symmetry, Frontier orbitals of ethene, 1,3- butadiene, 1,3,5-hexatriene and allylic systems. HOMO, LUMO concept, FMO approach. Classification of Pericyclic reactions. Woodward Hofmann rules for the following pericyclic reactions. Cycloadditions: Thermal and Photochemical 2+2 and 4+2 cycloadditions. Suprafacial and antrafacial cycloadditions. Electrocylic Reactions: Thermal and Photo-induced Electrocyclic reactions of 4n and 4n+2 systems and their stereochemistry. Conrotatory and disrotatory motions. Sigmatropic rearrangements: Classification, [1,3], [1,5] and [3,3] sigmatropic shifts. Cope and Claisen rearrangements. Suprafacial and antrafacial shifts of hydrogen atom.

Reference Books:

- Kurti, L., & Czako, B. *Strategic applications of named reactions in organic synthesis*. Burlington, MA: Elsevier Academic Press, 2004.

- Ahluwalia, V. K., & Parashar, R. K. *Organic reaction mechanisms*. Boca Raton, FL: CRC Press, 2002.
- Carruthers, W. *Modern methods of organic synthesis* (4th ed.). Cambridge, UK: Cambridge University Press, 2007.
- Carey, F. A., & Sundberg, R. J. *Advanced organic chemistry: Part A – Structure and mechanisms* (5th ed.). New York, NY: Springer, 2007.
- Mukherjee, S. M., & Singh, S. P. *Reaction mechanism in organic chemistry*. New Delhi, India: Macmillan India Limited, 2009.
- March, J., & Smith, M. B. *March's advanced organic chemistry: Reactions, mechanisms, and structure* (8th ed.). Hoboken, NJ: Wiley, 2020.
- Fleming, I. *Pericyclic reactions* (2nd ed.). Oxford, UK: Oxford University Press, 2015
- Clayden, J., Greeves, N., & Warren, S. *Organic chemistry* (2nd ed.). Oxford, UK: Oxford University Press, 2012.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Bio-inorganic & Group Theory				**Mid-Term:** 26 Marks
Code: MSCYT-202	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. S. A. Shah/Prof. Hamida Chisti/Dr. Adil Majeed				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the details of bio-inorganic chemistry and Group Theory

Course Outcomes	**CO1**	Understanding of Bioinorganic Chemistry of elements.
	CO2	To learn the different biochemical reactions that occurs in living systems.
	CO3	To learn the role of Metals in enzymes and medicine: anti-cancer agents, diabetes, arthritis, radionuclides and related applications.
	CO4	To learn Molecular Symmetry, Orthogonality Theorem and Applications of Group Theory

Module 1 [10L]	**Metal ions in Biochemical Systems** Introduction to bio-inorganic chemistry, Concept of essentiality, Criteria and classification of essential elements as per their role in living systems, Bulk metals and trace metals, Role of alkali and alkaline earth metals in biosystems, Metal ion toxicity, Na^+ - K^+ pump, Transport and storage of Iron (Ferritin, Transferrin and siderophores).
Module 2 [10L]	**Metalloporphyrins, Respiration & Electron Transport in Biosystems** Metalloporphyrins, Cytochromes (Cytochromes C, Cytochrome C-oxidase,Cytochrome P-450). Dioxygen transport (hemocyanin and hemerythrin),Structure and physiological role of hemoglobin and myoglobin, Bohr Effect andcooperativity, Chloride effect, Iron-Sulfur proteins, Ferredoxins, Rubredoxin,Copper proteins.
Module 3 [10L]	**Enzymes and medicinal Chemistry** Enzymes and co-enzymes, Structure and function of carboxypeptidase A, Carbonic anhydrase, Xanthine oxidase, Vitamin B12, Nitrogen fixation, Biochemical basis of essential metal deficient diseases (Iron, Zinc, Copper and Manganese deficiencies and consequences). Chelate therapy, Anticancer drugs-cisplatin, Vanadium complexes in medicine.
Module 4 [10L]	**Symmetry and Group Theory**: Identity, rotation axis, reflection plane, inversion centre, improper rotation axis. Combination of symmetry operations, Symmetry groups, Point groups, Classification and Identification of point groups. Matrix representation of symmetry operations and Great Orthogonality Theorem. Applications of group theory to Spectroscopy. Applications of symmetry to Molecular Chirality.

Reference Books:

- Huheey J.E., Inorganic Chemistry, 4th Edn., 2008, Pearson.
- Miessler G. L., Tarr D.A., Inorganic Chemistry, 3rd Edn., 2008, Pearson.
- Catherine E., Croft H., Sharpe A. G., Inorganic Chemistry, 2nd Edn., 2005.
- Cotton F. A., Wilkinson G., Murillo C. A., Bochmann M., Advanced Inorganic Chemistry, 6th Edn., 1999, Wiley.
- Weller and Armstrong, Inorganic Chemistry, 6th Edn., 2015, Oxford.
- Lee J. D., Concise Inorganic Chemistry, 5th Edn., 1999, Wiley,
- Atkins and Shriver, Inorganic Chemistry, 5th Edn., 2009.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Solid State Chemistry & Thermodynamics				**Mid-Term:** 26 Marks
Code: MSCYT-203	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. Kowsar Majid/Dr. Shrikant S Maktedar				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn and understand the solid state chemistry & thermodynamics

Course Outcomes	**CO1**	To learn and understand the factors responsible for the determination of structural properties of the solids
	CO2	To learn and understand the structural magnetic properties of solids
	CO3	To learn and understand irreversible thermodynamics
	CO4	To learn and understand statistical thermodynamics

Module 1 [10L]	**Crystal Structures and Systems** Introduction to crystal systems, Lattice energy of an ionic crystal, Born-Landes equation and Born-Haber cycle, Interlunar spacing in crystal system, X-ray diffraction, XRD pattern for cubic systems, XRD pattern for tungsten crystal, Types of crystals, Characteristics structures of ionic crystals, Metallic crystals, Free electron model of metals, band theory of solids, energy band theory of conductors, semiconductors and insulators, Superconductivity, LTSC and HTSC
Module 2 [10L]	**Properties of Solids** Magnetic properties: Magnetic Susceptibility, Paramagnetism in Metal Complexes, Ferromagnetic Metals, Ferromagnetic Domains, Permanent Magnets, Antiferromagnetism, Ferrimagnetism, Ferrites, Spiral Magnetism, Magnetoresistance, Giant and Tunneling Magnetoresistance, Colossal Magnetoresistance Magnets (CMR)
Module 3 [10L]	**Irreversible Thermodynamics** Basic principles of non-equilibrium thermodynamics: Second law of thermodynamics for open systems, law of conservation of mass, charge and energy. Irreversible processes and uncompensated heat, degree of advancement, reaction rate & affinity of a reaction. Relation of uncompensated heat to other thermodynamic functions. Entropy production, entropy production due to matter flow, heat flow, charge flow and chemical reactions; entropy production and efficiency of galvanic cells. Concept of forces and fluxes, Onsager's theory of irreversible processes, phenomenological laws, their domain of validity. Principle of microscopic reversibility and Onsager relations, Chemical reactions near equilibrium. Curie–Prigogine principle. Transformation properties of forces and fluxes.
Module 4 [10L]	**Statistical Thermodynamics** Ensembles-canonical, grand canonical and micro canonical Combinatorial problems, Thermodynamics probability and most probable distribution, Starlings approximation, distribution laws, the law of equipartition of energies. Quantum statistics- Max Well-Boltzmann, Bose-Einstein and Fermi-Dirac, limit and applicability of various distribution laws. Molecular Partition Function: Partition function, Expression for translational, rotational, vibrational and electronic partition functions, Third law of thermodynamics and partition function, Numerical problems.

Reference Books:

- West A. R., Solid State Chemistry and its Applications, 1989, Wiley.
- Atkins P. W., Physical Chemistry, 2010, Oxford
- Puri, Sharma, Pathania, Principles of Physical Chemistry, Vishal Publishing Co.

- Azaroff, Introduction to Solids, 1993, Tata McGraw.
- Ashcroft N. W., Mermin N. D., Solid State Physics, 2001, Saunders College.
- Srivastava J.P., Elements of Solid-State Physics, 2003, Prentice Hall of India.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Advanced Separation Techniques				**Mid-Term:** 26 Marks
Code: MSCYT-204	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Dr Mohammad Aslam				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the analysis of experimental data and learn various analytical separation techniques which would be applied in chemical science research, industries and quality control.

Course Outcomes	**CO1**	Gas chromatography and its application in industries/quality control labs.
	CO2	High-performance liquid chromatography and its application in industries.
	CO3	Ion-exchange chromatography and its application in biomedical and water treatment plants (industrial applications).
	CO4	Size exclusion and super critical fluid chromatography and its application in polymer science.

Module 1 [10L]	**Gas Chromatography** Introduction to chromatography, classification of chromatographic techniques, planar and column chromatography techniques. Principle of gas chromatography, instruments; carrier gases; columns and stationary phases; sample injection systems, detectors-characteristics of the ideal detectors, thermal conductivity detector, flame ionization detector, thermionic detector, mass spectrometer detector, factors affecting the efficiency of the column, important terminology for gas chromatograms, qualitative analysis, Kovats retention index (I), quantitative analysis, analyses based on peak height and peak areas, numeric problems based on gas chromatography, applications of gas chromatography.
Module 2 [10L]	**High Performance Liquid Chromatography** Introduction to high pperformance liquid chromatography, classification, pprinciple of HPLC, stationary and mobile phases in HPLC, instrumentation; isocratic and gradient elution, solvent delivery system, solvent degasser, sample injection system, separation columns and column packing, detectors, absorbance, UV-Visible detector, UV-PDA detector, refractive-index detector, and mass detector (HPLC-MS), basic difference between HPLC and conventional liquid chromatography, advantages and applications of HPLC.
Module 3 [10L]	**Ion-Exchange Chromatography** Introduction to ion/ion-exchange chromatography, classification of ion exchange chromatography, pprinciple of separation, instrumentation, pump, injector, column, suppresors, detectors. Ion-exchange equilibria and selectivity, types of stationary phases, strong and weak cation exchanger, strong and weak anion exchanger, mobile phases, effect of pH on separation of amino acid, effect of complexing agent on separation of metal ions. Analytical procedure for ion exchange chromatography, applications of ion exchange chromatography in water treatment plants and biochemistry field.
Module 4 [10L]	**Size Exclusion and Super Critical Fluid Chromatography** Size Exclusion Chromatography; principles of separation, components/ instrumentation of size exclusion chromatography, stationary phase, mobile phase, columns, pump, detectors, exclusion limit, total permeation and selective permeation regions, relation between elution volume and molecular weight, packing materials and applications. Super critical fluid chromatography and its properties, role of CO2 as supercritical fluid, principle, instrumentation, stationary and mobile phases, pump with back pressure

	regulator, modifiers, detectors, operating variables, advantages and limitations, applications.

Reference Books:

- Christian G. D., Dasgupta P. K., Schug K. A., *Analytical Chemistry*, Willey Publisher, 2020.
- Harvey D., *Modern Analytical Chemistry*, McGraw Hill Education, New York, 2000.
- Miller J. M., *Chromatography: Concepts and Contrasts*, 2nd Edition, Wiley-Interscience, 2004.
- Settle F.A., *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, 1997.
- Raymond P.W. S., *Introduction to Analytical Gas Chromatography*, Volume 76, CRC Press, 2017.
- Meyer V. R., *Practical High-Performance Liquid Chromatography*, 5th Edition, Willey, 2010.
- Robert L. G., Eugene F. B., *Modern Practice of Gas Chromatography*, 4th Edition, Wiley-Interscience, 2008.
- Miller L. M., Pinkston J. D., Taylor L. T., *Modern Supercritical Fluid Chromatography*: Carbon Dioxide Containing Mobile Phases (Chemical Analysis: A Series of Monographs on Analytical Chemistry and Its Applications, Wiley, 2019.
- Kaur H., *Instrumental Methods of Chemical Analysis,* 2012, Pragati Prakashan, Meerut, 2012.
- Chatwal G.R., Anand S. K., *Instrumental Methods of Chemical Analysis*, 5th Edition, Himalya Publishing House, New Delhi, 2019.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Biomolecules				**Mid-Term:** 26 Marks
Code: MSCYE-205	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Javid Ahmad Banday				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the structure and Functions of Bio-molecules.

Course Outcomes	**CO1**	To learn: - Structure, reactions and classification of Carbohydrates. - Structure, reactions and functions of amino acids and proteins.
	CO2	To gain knowledge about : - Nucleic acids and their role in living systems. - Lipids in daily life.
Module 1 [15L]		**Carbohydrates, Amino Acids and Proteins** Classification of carbohydrates: Monosaccharides: Structure with special reference to Glucose and Fructose, Configuration, Reactions, Anomers, Epimers and Epimerization, Mutarotation. Chain shortening and lengthening. Disaccharides and Polysaccharides; brief idea. Amino acids: Structure and Classification of Amino acids, Iso-electric point, Polypeptides and Proteins; Structure of Proteins (Primary, Secondary, Tertiary & Quaternary), Classification of Proteins. Peptide synthesis in laboratory.
Module 2 [15L]		**Nucleic Acids and Lipids** Introduction, Structure and Classification of Nucleic acids, Nucleosides, Nucleotides, base pairing in DNA. Functions of Nucleic acids; Nucleic acids and Heredity, Replication of DNA, Protein synthesis, Mutations. Lipids: Classification, Fats and Oils, Fatty acids, Steroids, Triglycerides, Phospholipids, Soaps and Detergents.

Reference Books:

- Clayden, J., Greeves, N., Warren, S., Wothers, P. Organic Chemistry, 3rd. Ed.; Oxford University Press, 2021.
- Satyanarayanan, U. and Chakrapani, U. Biochemistry- with Clinical Concepts and Case Studies, 4th. Ed.; Elsevier, 2013.
- McMurry, J. and Simanek, Eric. Fundamentals of Organic Chemistry, 7th. Ed., (Cengage India Pvt. Ltd.), 2010.
- David, L. N. and Michael M. C. Principles of Biochemistry, 6th. Ed.; W. H. Freeman 2013.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Nuclear Chemistry				**Mid-Term:** 26 Marks
Code: MSCYE-206	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Hamida Chisti				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable students to learn the details of nuclear chemistry

Course Outcomes	**CO1**	To understand the details of nuclear chemistry
	CO2	To learn about Nuclear Fission, Fusion, Radiotracers and its applications
Module 1 [15L]		**Nuclear Chemistry:** Introduction, Nuclear binding energy, Mass defect and binding energy, The average binding energy per nucleon. Radioactivity: Nuclear emissions, nuclear transformations, The kinetics of radioactive decay, Units of radioactivity. Artificial isotopes: Bombardment of nuclei by high-energy α-particles and neutrons, Bombardment of nuclei by 'slow' neutrons.
Module 2 [15L]		**Nuclear Fission, Nuclear Fusion and Radiotracers:** Nuclear fission: The fission of uranium-235, The production of energy by nuclear fission, nuclear reprocessing. Syntheses of trans uranium elements. The separation of radioactive isotopes: Chemical separation, Nuclear fusion. Applications of isotopes. Radiotracers, Medical Applications of Radiotracers (Positron Emission Tomography)

Reference Books:

- Huheey J. E., Inorganic Chemistry, 4th Edn., 2008, Pearson.
- Miessler G. L., Tarr D.A., Inorganic Chemistry, 3rd Edn., 2008, Pearson.
- Catherine E., Croft H., Sharpe A. G., Inorganic Chemistry, 2nd Edn., 2005.
- Loveland W. D, Morrissey D. J., Seaborg G. T., Modern Nuclear Chemistry 2006, Wiley

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Energy Conversion & Storage Systems				**Mid-Term:** 26 Marks
Code: MSCYE-207	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Dr. Shrikant Shivaji Maktedar				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to understand & learn the energy conversion & storage systems through electrochemical techniques.

Course Outcome	**CO1**	To learn and understand various electrochemical techniques for diverse applications
	CO2	To learn and understand representative energy storage and conversion systems with various mechanistic aspects
Module 1 [15L]		**Electrochemical Techniques** Cyclic Voltammetry, Linear Sweep Voltammetry, Electrochemical Impedance Spectroscopy, Differential Pulse Voltammetry, Chronoamperometry, Chronopotentiometry, Galvanostatic Charge Discharge, with representative examples of each technique by using suitable materials, Principle and Examples of Energy Conversion and Storage Systems
Module 2 [15L]		**Energy Storage and Conversion Devices** Modes of Electrical Energy Storage by Capacitors and Batteries, Faradaic and Non-Faradaic Processes, Types of Capacitors and Types of Batteries, Differences of Densities of Charge Storage in Capacitors and Batteries, Comparison of Capacitor and Battery, Properties of Electrochemical Capacitors and Batteries, Supercapacitors, Battery and Fuel Cells: Principles, Examples and Applications

Reference Books:

- Electrochemical Methods: Fundamentals & Applications, Allen J Bard, Larry R Faulkner, Second Edition, John Wiley & Sons Inc.
- Electrochemical Supercapacitors: Scientific Fundamentals & Technological Applications, B. E. Conway

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Bioinspired Surface Engineering				**Mid-Term:** 26 Marks
Code: MSCYE-208	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Dr. Adil Majeed Rather				**Class-Assessment:** 24 Marks

Course Objective: To provide students with a comprehensive understanding of biomimetic principles, surface wettability, and advanced fabrication strategies for designing bioinspired surfaces, along with their applications in self-cleaning, anti-corrosion, biomedical, energy, and sustainable engineering systems.

Course Outcomes	**CO1**	Understand the fundamental principles of bioinspired surface engineering, natural wetting phenomena, and fabrication strategies used for developing functional biomimetic surfaces.
	CO2	Analyze the applications, performance, and industrial relevance of bioinspired functional materials for self-cleaning, anti-corrosion, biomedical, energy, and sustainable engineering applications.
Module 1 [15L]		**Fundamentals and Fabrication of Bioinspired Surfaces** Introduction to biomimetics and bioinspired engineering, surface tension and surface energy, Young's equation, Wenzel and Cassie–Baxter wetting models, contact angle and sliding angle measurements, superhydrophobicity and superoleophobicity, anisotropic wetting and directional liquid transport, Natural bioinspired systems, including lotus leaf-inspired self-cleaning surfaces, fish scale-inspired underwater superoleophobic surfaces, pitcher plant-inspired slippery liquid infused porous surfaces (SLIPS), and desert beetle-inspired water collection systems, fabrication techniques including lithography, sol–gel, electrospinning, chemical etching, and layer-by-layer assembly methods.
Module 2 [15L]		**Applications and Emerging Trends in Bioinspired Functional Materials** Applications of bioinspired functional materials including self-cleaning, anti-corrosion and anti-icing surfaces, oil–water separation membranes, biomedical and antibacterial coatings, drag reduction and marine coatings. Challenges and future prospects, including durability, scalability, industrial commercialization, multifunctional surfaces, smart and stimuli-responsive materials.

Reference Books:

- Bhushan. B, Biomimetics: Bioinspired Hierarchical-Structured Surfaces for Green Science and Technology, Springer, 2016.
- Zhenhai. X, Biomimetic Principles and Design of Advanced Engineering Materials, Wiley, 2016.
- Bhushan. B, Springer Handbook of Nanotechnology, Springer, 2017.
- Zheng, Y. Bioinspired design of materials surfaces, Elsevier, 2019.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Organic Chemistry Laboratory – II				**Continuous Assessment:** 60 Marks
Code: MSCYL-209	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher In charge: Prof. Tabassum Ara/Prof. J. A. Banday/Dr. Ravi Kumar				

Course Objective: The course has been designed to enable the students to learn the organic chemistry practical skills.

Course Outcome	**CO1**	Synthesis of Organic Compounds
	CO2	Isolation of Natural Products
	CO3	Characterization of Organic Compounds by IR Spectroscopy
	CO4	Determination of λ_{max} of Organic Compounds

Exp. 1-4	**Preparations of the following compounds** 1. Aspirin from salicylic acid 2. Haloform reaction: Preparation of Iodoform. 3. Nitrobenzene to m-dinitrobenzene to m-nitroaniline 4. Benzophenone_Benzophenoneoxime_Benzanilide (Beckmannrearrangement) 5. Aniline to Diazonium salt to p-Aminoazobenzene 6. Glucazone from glucose 7. Benzoin to Benzil to Benzilic Acid
Exp. 5-6	**Isolation of** 1. Caffeine from tealeaves 2. Lycopene from tomatoes 3. Casein from milk
Exp. 7-8	**Detection of functional groups** using IR spectroscopy in a given organic compound (Two exercises).
Exp. 9-10	**Determination** of λmax for a given organic compound using UV-Vis spectrophotometer. (Two exercises).

Reference Books:

- Vishnoi N.K., Advanced Practical Organic Chemistry, 2nd ed. 1999, Vikas
- Pasto D., Johnson C., Miller M., Experiments and Techniques in Organic Chemistry, 1992, Prentice-hall
- Williamson K.L., Microscale and Macroscale Organic Experiments, 1989, D.C. Heath and Co.
- Tatchell A.R., Vogel's Textbook of Practical Organic Chemistry, 5th ed.- 1996.
- Ahluwalia V. K., Aggarwal R., Comprehensive Practical Organic Chemistry, 2000, University Press.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Inorganic Chemistry Laboratory – II				**Continuous Assessment:** 60 Marks
Code: MSCYL-210	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher In charge: Prof. S. A. Shah/Prof. Hamida Chisti				
Course Objective: To gain practical knowledge of inorganic chemistry				

Course Outcomes	**CO1**	Synthesis of coordination complexes.
	CO2	Structure elucidation of inorganic complexes.
	CO3	Spectrophotometric determination.
	CO4	Estimation of metal ions.

Exp. 1	Synthesis of dichlorobis (triphenylphosphine) cobalt (II).
Exp. 2	Synthesis of tris (2,4-pentadionato) chromium (III).
Exp. 3	Synthesis of dichlorobis (triphenylphosphine) nickel (II).
Exp. 4	Synthesis of Ammonium dodecamolbedophosphate.
Exp. 5	Synthesis of cis-Potassium dioxalatodiaquachromate(III), i.e., cis-$K[Cr(C_2O_4)_2(H_2O)_2]$.
Exp. 6	Synthesis of Tetraamminecopper (II) Sulphate monohydrate: $[Cu(NH_3)_4]SO_4.H_2O$.
Exp. 7	Synthesis of tris (ethylenediamine) cobalt (III) chloride.
Exp. 8	Synthesis of Mercurytetrathiocyanatocobaltate (II).
Exp. 9	Determination of the amount of (Fe^{2+}) in the given sample spectrophotometrically using 1,10-phenanthroline.

Reference Books:

- Vogel A. I., Qualitative Inorganic Analysis, 6th Edition Revised, G. Svehla, ELB– London.
- Vogel A. I., Textbook of Chemistry Analysis.
- Raj G., Advanced Practical Inorganic Chemistry, Goel Publishing House, Meerut.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Physical Chemistry Laboratory – II				**Continuous Assessment:** 60 Marks
Code: MSCYL-211	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher In charge: Prof. Kowsar Majid				

Course Objective: The laboratory course has been designed to enable the students to learn the concepts in physical chemistry through practical sessions

Course Outcome	**CO1**	To learn the principal & concepts of potentiometric technique
	CO2	To learn the principal & concepts of conductometric technique
	CO3	To learn and validate the concepts in chemical kinetics & surface chemistry
	CO4	To learn and understand the concepts of pH and Spectrophotometry

Exp. 1	Titration of Fe (II) vs $K_2Cr_2O_7$ and determination of the standard redox potential of Fe^{2+}/Fe^{3+}.
Exp. 2	Determination of acidic and basic dissociation constants of an amino acid and hence the isoelectric point of the acid.
Exp. 3	Titration of a mixture of HCl and CH_3COOH potentiometrically, and hence the composition of the mixture.
Exp. 4	Determine the composition of a mixture of acetic acid and hydrochloric acid by conductometric titration.
Exp. 5	Determine the concentration of H_2SO_4, CH_3COOH and $CuSO_4$ in a given mixture of solution by carrying out conductometric titration with NaOH.
Exp. 6	Determine the equivalent conductance of KCl at several concentrations and hence verify the Onsager equation.
Exp. 7	Determine the order of hydrolysis of ethyl acetate by titrating with sodium hydroxide.
Exp. 8	Determine the equilibrium constant of the reaction. $Ag(NH_3)_2^+ \leftrightarrow Ag^+ + 2NH_3$
Exp. 9	Determination of the composition of a binary mixture of $K_2Cr_2O_7$ and $KMnO_4$ using a spectrophotometer.
Exp. 10	Determine the pH of a buffer solution with pH (less than 8) using a Quinhydrone electrode

Reference Books:

- Wilson J.M., Newcombe K.J., Denko A.R., Richett R.M.W., Experiments in Physical Chemistry, Pergamon Press
- Findary A., Kitchner T.A., Practical Physical Chemistry, Longmans, Green and Co.
- Khosla B.D., Garg V.S., Senior Practical Physical Chemistry, R. Chand and Co., Delhi.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Organic Spectroscopy and Modern Organic Synthesis				**Mid-Term:** 26 Marks
Code: MSCYT-301	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. Tabassum Ara				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn various spectral techniques and designing the synthesis of organic molecules.

Course Outcome	**CO1**	Organic structure determination using spectroscopic techniques.
	CO2	Photochemical excitation/de-excitation events.
	CO3	Modern synthetic methods used in functional group transformations.
	CO4	Retrosynthetic approach in the art of modern organic synthesis.

Module 1 [10L]	**UV, IR Spectroscopy and Mass Spectrometry** UV Spectroscopy: Electronic transitions in organic molecules, Woodward-Fieser rules for alkenes, Woodward rules for enones and aromatic compounds IR Spectroscopy: IR frequencies of alkanes, alkenes, alkynes, aromatic compounds, and for all other functional groups. Effects of hydrogen bonding and solvent on vibrational frequencies, overtones, combination bands and Fermi resonance. Mass spectrometry: Basic principles, hard and soft ionization techniques, mass analyzer in ESI-MS and MALDI-MS, high resolution MS, isotope abundance, molecular ion, fragmentation processes (McL) of organic molecules, deduction of structure through mass spectral fragmentation, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule High resolution mass spectrometry
Module 2 [10L]	**Nuclear Magnetic Resonance Spectroscopy** Basic concepts, Mechanism of Measurements, Chemical shift values for various classes of compounds. Fourier Transform (FT) Techniques and advantages, Nuclear OVERHAUSER effect (NOE). One bond coupling, two bond coupling, three bond coupling, second order spectra A2, AB, AX, AB2, AX2, A2B2. Proton exchange, deuterium exchange, Peak broadening exchange
Module 3 [10L]	**Photochemistry** Photochemical Reactions, Interaction of electromagnetic radiation with matter. Types of excitations. Singlet and triplet states and their lifetimes. Fate of excited molecule: Physical and chemical processes. Transfer of excitation energy: Sensitization and Quenching. Photochemistry of alkenes, Geometrical isomerisations, cyclisation and dimerization reactions. Photochemical reactions of 1,3- butadiene (excluding pericyclic reactions). Rearrangements of 1,4 and 1,5- dienes. Photochemistry of saturated carbonyl compounds, Intramolecular reactions of saturated acyclic and cyclic carbonyl compounds. (Norrish type-I and Norrish type-II processes). Intermolecular cycloaddition reactions (Paterno- Buchi reaction). Photochemistry of unsaturated carbonyl compounds, Photochemical reactions of □, □-unsaturated carbonyl compounds. (H-Abstraction and isomerization to □, □-unsaturated carbonyl compounds). Photolysis of cyclic □, □- unsaturated ketones (dimerization and lumiketone rearrangement) and cyclohexadienones
Module 4 [10L]	**Designing Organic Synthesis** Retrosynthetic analysis: Basic principles and terminology of retrosynthesis, guidelines, one group and two group C-X disconnections, one group C-C and two group C-C disconnections, amine and alkene synthesis, important functional group interconversions, reversal of polarity (umpolung).

	Protection and deprotection of functional groups: Protection and de-protection of hydroxy, carboxyl, carbonyl, amino acids

Reference Books:

- Smith M.B., Organic Synthesis, 3rd Ed., 2010, Academic Press.
- Warren S., Wyatt P., Organic Synthesis: The Disconnection Approach, 2nd Edition, 2008, Wiley-VCH.
- Carey F.A., Sundberg R.J., Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th Edition, 2007, Plenum.
- Clayden J., Greeves N., Warren S., Organic Chemistry, 2nd Ed., 2012, Oxford.
- Kemp W., Organic Spectroscopy, 3rd Edition, 2009, Macmillan.
- Pavia D. L., Lanyman G. M, Introduction to Spectroscopy, 3rd Edition, 2008, Thompson Publishers.
- Kalsi P.S., Spectroscopy of Organic Compounds, 6th Edition, 2004, New Age International Publishers.
- Sharma Y. R., Elementary Organic Spectroscopy-Principles and Applications, 5th Edition, 2007, S. Chand Publishers.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Organometallic Chemistry				**Mid-Term:** 26 Marks
Code: MSCYT-302	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Prof. S. A. Shah/Dr. Adil Majeed				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to understand organometallic chemistry.

Course Outcomes	**CO1**	Study of metal carbonyls in organometallic chemistry.
	CO2	Synergistic effect of ligands in metal complexes.
	CO3	To learn about the spectral analysis, Metal-Metal bonding & clusters of organometallic complexes.
	CO4	To understand the industrially important homogenous catalysis cycles.

Module 1 [10L]	**Metal Carbonyls** Organic Ligands and Nomenclature. The 18-electron Rule: Counting electrons in octahedral, tetrahedral and square planar complexes. Ligands in Organometallic chemistry: Carbonyl complexes, Ligands similar to carbonyl, hydride and dihydrogen complexes, ligands having extended pi systems. Bonding between metals and organic pi systems: Linear pi systems, cyclic pi- systems, and fullerene complexes. Complexes containing M-C, M=C and M≡C bonds: Alkyl and related complexes, Carbene and Carbyne complexes
Module 2 [10L]	**Metal Nitrosyls** Introduction, modes of bonding of NO as NO+, Nitrosylating agents for synthesis of metal nitrosyls, Structure, bonding and important reactions of transition metal nitrosyls, Vibrational spectra for structural elucidation and bondig in metal nitrosyls. Structure of Roussins red and black salts. Dinitrogen, dioxygen and tertiary phosphine as Ligands. Bonding Schemes
Module 3 [10L]	**Metal Clusters** Spectral analysis and characterisation of organometallic complexes: Infra-red spectra and NMR spectra. The Isolobal Analogy: Extensions of the Analogy. Metal-Metal bonds, Multiple Metal-Metal bonds. Cluster compounds: Boranes, Heteroboranes, Metallo-boranes and MetalloCarboranes, Carbonyl Clusters, Carbide Clusters. Metal Halide Clusters: major structural types in Dimuclear Metal-Metal systemsEdge Sharing Bioctahedra, face sharing Bioctahedra, Tetragonal prismatic and trigonal antiprismetic structures, Quadruple bonds, Structure and bonding in $(Re_2Cl_8)^{2-}$
Module 4 [10L]	**Organometallic Reactions** Reactions involving gain or loss of ligands: Ligand dissociation and substitution,oxidative addition, reductive elimination, nucleophilic displacement. Reactions involving modification of ligands: Insertion, Carbonyl insertion (Alkylmigration), 1, 2 Insertions, Hydride elimination, abstractions. Organometallic Catalysis: examples of Catalysis (Catalytic Deuteration), Hydroformylation, Monsanto acetic acid process, Wacker (Smidt) process, Hydrogenation by Wilkinson's Catalyst, Olefin Metathesis. Heterogeneous catalyst: Ziegler-Natta Polymerization and water gas reaction.

Reference Books:

- Huheey J. E., Inorganic Chemistry, 4th Edn., 2008, Pearson
- Miessler G. L., Tarr D.A., Inorganic Chemistry, 3rd Edn., 2008, Pearson.
- Cotton F. A., Wilkinson G., Murillo C. A., Bochmann M., Advanced Inorganic Chemistry, 6th Edn., 1999, Wiley.

- Weller and Armstrong, Inorganic Chemistry, 6th Edn., 2015, Oxford.
- Lee J. D., Concise Inorganic Chemistry, 5th Edn., 1999, Wiley,
- Atkins and Shriver, Inorganic Chemistry, 5th Edn., 2009.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Quantum Chemistry				**Mid-Term:** 26 Marks
Code: MSCYT-303	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Dr. Shrikant Shivaji Maktedar				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the quantum chemistry.

Course Outcome	
CO1	To learn & understand the basic systems in quantum mechanics
CO2	To learn and understand atomic spectra with some advanced concepts
CO3	To learn & understand molecular quantum mechanics
CO4	To apply the learned concepts through tutorials

Module 1 [10L]	**Wave Mechanical Treatment of Simple Systems** Quantum theory of radiation, Photoelectric effect, Quantum mechanics/wave mechanics, Postulates, The Schrodinger wave equation, Operators in quantum mechanics, Hermitian operators, Particle in 1-D and 3-D box, One dimensional simple harmonic oscillator, Angular momentum in quantum mechanics
Module 2 [10L]	**Advanced Topics and Atomic Spectra** Angular momentum operators, Eigen functions, eigenvalues, commutation relations and ladder operators, Atomic states and term symbols, Determination of ground state term symbols for various configurations, Atomic spectra, Fine structure, Zeeman effect, Stark effect
Module 3 [10L]	**Molecular Quantum Mechanics** Huckel rule, Applications. Huckel Molecular Orbital Theory of Conjugated Systems, Application to Ethylene, Butadiene, Cyclopropenyl Radical, Cyclobutadiene and Benzene, Numericals.
Module 4 [10L]	**Tutorial** Numericals in quantum mechanics, MCQ's, class presentation/assignments

Reference Books:

- McQuarie D. A., Quantum Chemistry, Student Edn., 2018, Viva Books Pvt Ltd.
- 2. Prasad R. K., Quantum Chemistry, 4th Edn., 2010, New Age Publishers.
- 3. Levine I. N., Quantum Chemistry, 7th Edn. 2013., Prentice Hall.
- 4. Atkins P. W., Physical Chemistry, 8th Edn. 2006, Oxford University Press.

Subject: Advanced Characterization Techniques				**Mid-Term:** 26 Marks
Code: MSCYT-304	**Credits:** 3	L [2] : T [1] : P [0]	**Hours:** 40	**End-Term:** 50 Marks
Teacher In charge: Dr Mohammad Aslam				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the advanced and sophisticated materials characterization techniques that would be applied in material science/chemical science research and industries.

Course Outcomes	**CO1**	Advanced surface morphology characterization techniques like SEM & TEM.
	CO2	Raman spectroscopy and its application in material science/chemical analysis.
	CO3	Fourier Transform Infrared spectrometry and its application in chemistry/material characterization, industries.
	CO4	Mass spectrometry and its application in chemistry/material characterization.

Module 1 [10L]	**Electron Microscopy** Introduction to electron microscopy, classifications of electron microscopy, scanning electron microscopy (SEM); fundamentals, significance of secondary electrons, back-scattered electrons and X-ray photons, sample preparation, working, instrumentation and its applications in surface morphology determination. Transmission electron microscopy (TEM); Introduction, basic theory and principle, instrumentation, sample preparation, specimen orientation, electron gun, electromagnetic lens, condenser lens, objective lens, projector lenses, imaging, operating parameters-magnification, resolution, comparative analysis of SEM and TEM, applications.
Module 2 [10L]	**Raman Spectroscopy** Principle, theory, excitation of Raman spectra, mechanisms of Raman and Rayleigh scattering, Raman effect, elastic and non-elastic collision, wave model of Raman and Rayleigh scattering, intensity of normal Raman bands, theories of Raman effect, classical theory of Raman scattering, quantum theory of Raman scattering, limitations of Raman theories, instrumentation of Raman spectrometer, sources, sample-Illumination system, applications of Raman spectroscopy in inorganic, organic and biological species and Quantitative Applications), Problems.
Module 3 [10L]	**Fourier Transform Infrared Spectrometry** Introduction to FTIR Spectroscopy, theory of Infrared absorption: molecular vibrations (stretching and bending), dipole moment changes, IR-active vs. IR-inactive vibrations, fundamental principles, interaction of Infrared radiation with matter, frequency range, wave-number, FTIR instrumentation, sample preparation (solids, liquids, gases), FTIR components, radiation sources, Fourier transform process, Michelson interferometer, interferogram generation, beam splitter material, thermal detectors, photon detectors, data acquisition and processing, applications and data interpretation; qualitative analysis, identifying functional groups using the group frequency region and fingerprint region, quantitative analysis, applications in industry (polymer/pharmaceutical)/Research, advantages and limitations of FTIR.
Module 4 [10L]	**Mass Spectrometry** Introduction, principle of mass spectrometry, ion production, electron ionization (EI), chemical ionization (CI), field ionization (FI), mass to charge ratio. Mass spectrometers, components of mass spectrometer, sample handling system, ionization chamber, electrostatic accelerating system, ion separator, ion collector, vacuum system, mass analyzers, sector analyzer, quadrupole mass analyzer, time of flight mass analyzer,

	resolution, applications of mass spectrometry to volatiles/non-volatiles. Introduction to advanced mass spectrometry; high resolution-mass spectrometry (HR-MS), and their applications.

Reference Books:

- Settle F.A., *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, 1997.
- Leng Y., *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Wiley & Sons, 2008.
- Harvey D., *Modern Analytical Chemistry*, McGraw Hill Education, New York, 2000.
- Skoog D., Holler F., Crouch S., *Principles of Instrumental Analysi*s, 7th Edition, Cengage Learning Publication, 2017.
- Willard H.M., Merritt L.L., Dean J.A., Settle F.A., *Instrumental Methods of Analysis*, 7th Edition, CBS Publisher, 2020.
- Hollas J. M., *Modern Spectroscopy*, 4th Edition, Wiley, 2013.
- Goldstein J., Newbury D.E., Joy D.C., Lyman C. E., *Scanning Electron Microscopy and X-Ray Microanalysis*, 3rd Edition, Springer, 2013.
- Echlin P., Fiori C.E., Goldstein J., Joy D. C., Newbury D. E., *Advanced Scanning Electron Microscopy and X-Ray Microanalysis*, Springer, 2013.
- Chatwal G.R., Anand S.K., *Instrumental Methods of Chemical Analysis*, 5th Edition, 2019, Himalya Publishing House, New Delhi, 2019.
- Kaur H., *Instrumental Methods of Chemical Analysis,* 2012, Pragati Prakashan, Meerut, 2012.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Applied Organic Chemistry				**Mid-Term:** 26 Marks
Code: MSCYE-305	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Tabassum Ara				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn the Chromatographic techniques, role of food additives, drugs and enzymes.

Course Outcome	**CO1**	To acquire knowledge about applications of Chromatographic techniques. To know the role of food additives
	CO2	To understand the role of drugs in curing various diseases To have knowledge about enzymes and their activity
Module 1 [15L]		**Chromatographic Techniques** Introduction, applications of chromatography, various types of chromatographic techniques. Thin layer chromatography, Paper chromatography, Column chromatography. **Food Additives** Introduction, Various types of food additives and their role. Food preservatives, various nutritious additives. Sweetening agents: Natural and Artificial
Module 2 [15L]		**Drugs** Introduction, chemotherapy, classification of drugs, Antipyretics, Analgesics, Antibiotics, Diuretics, Disinfectants, Antiseptics, Antihistamines, Tranquilizers, Antiacids. **Enzymes** Introduction, Nomenclature and classification, Chemical nature and Properties of enzymes, Factors affecting enzyme activity

Reference Books:

- R.F. Doerge, Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, J. Lippincott Co., Philadelphia.
- Burger's Medicinal Chemistry and Drug Discovery, Vol. I. Principle and Practice, 5th,
- Handbook of Food Preservation by M. Shafiur Rahman. Edition, John Wiley Sons, New York.
- Chromatography: Concepts and Contrasts by James, M. Miller, Wiley Online Library First Edition 2009.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Nanotechnology				**Mid-Term:** 26 Marks
Code: MSCYE-306	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Hamida Chisti				**Class-Assessment:** 24 Marks

Course Objective: To impart the basic knowledge on nanotechnology which includes the exotic properties of materials at nanoscale, various techniques available for the processing and characterization of nanostructured materials and their applications.

Course Outcome	**CO1**	To familiarize the students with the basic knowledge of nanotechnology.
	CO2	To familiarize the students with the Synthesis and applications of conducting and biopolymer-based nanocomposites
Module 1 [15L]		**Fundamentals of Nanotechnology:** Fundamentals of nanotechnology, introduction to nano-scale, nanocomposites, Advanced Inorganic materials, Nanotechnology & its industrial application, potential application of inorganic nanomaterials. General methods of Preparation: Top-down approach and bottom-up approach for synthesis of nanomaterial, Ball milling, Sol-gel method, Solution based method, Solvothermal synthesis, and photochemical synthesis
Module 2 [15L]		**Conducting and Biopolymer polymer-based nanocomposites:** Conducting polymer-based nanocomposites: General introduction of conducting polymer-based nanocomposites (Polypyrrole, polyaniline) Types of conducting polymer-based nanocomposites, Synthesis of Conducting polymer-based nanocomposites (Precipitation method, Co-precipitation method, Sol-gel method), Applications of conducting polymer-based nanocomposites. Biopolymer-based nanocomposites: General introduction of Biopolymer-based nanocomposites (Starch, Chitosan, Gelatin, Pectin, Alginate, and Cellulose), Types of biopolymer-based nanocomposites, Synthesis of biopolymer-based nanocomposites (Precipitation method, Co-precipitation method, Sol-gel method), Applications of biopolymer-based nanocomposites.

Reference Books:

- Cao G., Nanostructures and Nanomaterials–Synthesis, Properties and Applications, 2004, Imperial College Press, London.
- Rao C. N. R., Muller A., Cheetham A. K.,The Chemistry of Nanomaterials, Volume 1, 2004, Wiley –VCH Verlag GmbH & Co. KGaA, Weinheim.
- Awan, T. I., Bashir A., Tehseen A., Chemistry of Nanomaterials: Fundamentals and Applications,2020, ISBN: 978-0-12-818908-5

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Organic Flexible Electronics Materials				**Mid-Term:** 26 Marks
Code: MSCYE-307	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Kowsar Majid				**Class-Assessment:** 24 Marks

Course Objective: The course has been designed to enable the students to learn about organic flexible electronic devices.

Course Outcome	**CO1**	Analyze the electronic properties, charge transport mechanisms, fabrication techniques, and device architectures of flexible organic semiconducting materials and devices.
	CO2	Evaluate the influence of morphology, mechanical reliability, and degradation mechanisms on the stability and performance of flexible electronic devices.
Module 1 [15L]		**Advanced Flexible Electronic Materials** Electronic structure and charge transport mechanisms in π-conjugated polymers and organic semiconductors ;Thin-film fabrication techniques for flexible electronics: vapor-phase deposition, solution processing, and printing methods; Interfacial energetics, charge injection, doping, band alignment, and morphology control in organic heterostructures; Mechanical reliability and degradation mechanisms in flexible organic electronic devices; Advanced materials and interface engineering strategies for high-performance flexible and stretchable electronics
Module 2 [15L]		**Flexible Organic Electronic Devices and Emerging Applications** Device physics and architectures of flexible OLEDs, OFETs, and organic optoelectronic systems; Polymer solar cells and mixed heterojunction photovoltaic devices: materials, mechanisms, and efficiency enhancement; Flexible photodetectors and organic optoelectronic devices for communication technologies. Organic electronic devices for wearable chemical, biological, and biomedical sensing applications ;Emerging trends in printed, transparent, stretchable, self-healable, and bio-integrated flexible electronic systems.

Reference Books:

- *Flexible Electronics: Materials and Applications, 1st Edition, Springer, 2009.* (Wong, Salleo – fundamentals of flexible systems and mechanics)
- *Organic Electronics: Materials, Manufacturing, and Applications, 1st Edition, Wiley-VCH, 2006* (Hagen Klauk)
- *Physics of Organic Semiconductors, 2nd Edition, Wiley-VCH, 2012.*(Brütting & Adachi)
- *Electronic Processes in Organic Semiconductors, 1st Edition, Wiley-VCH, 2015.* (Anna Köhler & Heinz Bässler)
- *Organic Field-Effect Transistors, 1st Edition, CRC Press, 2007,* Zhenan Bao & Jason Locklin
- *Handbook of Flexible Organic Electronics, 1st Edition, Woodhead Publishing, 2014.* (Comprehensive reference covering materials, devices, and applications)

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Metal-Organic Frameworks: Fundamentals & Applications				**Mid-Term:** 26 Marks
Code: MSCYE-308	**Credits:** 3	L [3] : T [0] : P [0]	**Hours:** 30	**End-Term:** 50 Marks
Teacher In charge: Prof. Kowsar Majid				**Class-Assessment:** 24 Marks

Course Objective: To introduce students to the design, synthesis, characterization, and applications of Metal–Organic Frameworks (MOFs) as advanced porous materials for energy, environmental, and biomedical applications.

Course Outcome	**CO1**	To Explain the structural features and chemistry of MOFs, Understanding different synthesis routes.
	CO2	To Evaluate MOF applications in various fields, Relate structure with functionality, Understand current research trends in MOF science.
Module 1 [15L]		**Fundamentals of MOFs** Introduction to porous materials and MOFs , Historical development of MOFs, Basics of coordination chemistry and crystal engineering ,Structure of MOFs: Metal ions/clusters ,Organic linkers ,Secondary Building Units (SBUs) ,Topology and pore architecture ,Synthesis methods, Solvothermal and hydrothermal synthesis, Microwave-assisted synthesis, Mechanochemical synthesis
Module 2 [15L]		**Applications and Advanced Developments in Gas storage and Separation** Hydrogen storage, CO_2 capture, Catalytic applications, Heterogeneous catalysis ,Photo catalysis, Environmental applications, Water purification, Dye and heavy metal adsorption, Biomedical Apllications, Drug delivery, Biosensing, Energy applications: Batteries ,Supercapacitors, Advanced MOFs: Conductive MOFs ,Flexible MOFs ,MOF composites and derivatives ,Current challenges and future prospects.

Reference Books:

- The Chemistry of Metal–Organic Frameworks, Stefan Kaskel, Wiley-VCH Verlag GmbH & Co. KGaA, Year: 2016.ISBN: 978-3527338740
- Metal–Organic Frameworks: Applications from Catalysis to Gas Storage,David Farrusseng Wiley-VCH Verlag GmbH & Co. KGaA,2011,ISBN: 978-3527326471
- Introduction to Reticular Chemistry, Authors: Omar M. Yaghi, Michael O'Keeffe, and Hong-Cai Zhou,Publisher: Wiley-VCH,Year: 2019,ISBN: 978-3527345007
- Metal-Organic Frameworks (MOFs) for Environmental Applications, Editors: Inamuddin, Asiri A. M., and Mohammad Ahamed, Publisher: Springer Nature,Year: 2020,ISBN: 978-3030422530

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Analytical Chemistry Lab				**Cont. Assessment:**60 Marks
Code: MSCYL-309	**Credits:** 1	L [0] : T [0] : P [3]	**Hours:** 30	**End-Term:** 40 Marks
Teacher Incharge: Dr Mohammad Aslam				**Total:** 100 Marks

Course Objective: To develop the experimental skills by providing hands on experience on various instrumental techniques used in Chemistry and to make the student competent to design, perform and analyse the experiments by using these techniques.

Course Outcome	**CO1**	Titrimetric analysis and its application in purity analysis.
	CO2	Solid-liquid extraction using Soxhlet apparatus and its application in Chemistry.
	CO3	Conductometric determination of strength of mixture of acids and base.
	CO4	Chromatographic separation and identification of mixture's components.
Exp. 1		Determination of Ca^{2+} in milk powder/water by EDTA complexometric titration.
Exp. 2		Analysis of calcium oxide in cement/white cement complexometrically.
Exp. 3		Determination of concentration of acetic acid in vinegar sample.
Exp. 4		Estimation of phosphoric acid content in soft/cold drinks.
Exp. 5		Extraction of oil (wt.%) from ground nuts using Soxhlet unit.
Exp. 6		Determination of acid index/iodine value of an oil/fat using Wijs method.
Exp. 7		Estimation of paracetamol content in analgesic tablets using spectrophotometer.
Exp. 8		Determination of strength of strong and weak acids in a given mixture conductometrically.
Exp. 9		Separation of plant pigments from extracts of leaves/flowers by paper chromatography and determination of Rf values.
Exp. 10		Determination and quantification of liquid hydrocarbons using GC-MS technique.

Reference Books:

- Mendham J., *Vogel's Quantitative Chemical Analysis*, 6th Edition, Pearson Education, 2009.
- Geleta G.S., Tola K.B., *Practical Chemistry: Instrumental Analysis and Quantitative Analytical Chemistry,* De Gruyter, 2025.
- Holloway M.D., *The Analytical Chemistry Laboratory Companion*, Wiley-Scrivener, 2025.
- Samant R.A., Wadhawa G.C., Jain K.P., Mal P.K., Janwadkar S.P., *Analytical Chemistry Practical*, Himalya Publishing House, New Delhi, 2025.
- Popat P.R., *Practical Book of Analytical Chemistry* (First Edition), Notion Press Media Pvt Ltd., 2020.

DEPARTMENT OF CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY, SRINAGAR

Subject: Computer Methods in Chemistry Lab				**Cont. Assessment:**60 Marks
Code: MSCYL-310	**Credits:** 1	L [0] : T [0] : P 4]	**Hours:** 40	**End-Term:** 40 Marks
Teacher Incharge: Dr Mohammad Aslam				**Total:** 100 Marks

Course Objective: The course objective is to provide software knowledge and skills to address the needs in chemistry and related areas.

Course Outcomes	**CO1**	Formula creation in MS Office, calculation of correlation coefficient.
	CO2	Orgin software in graph plotting and getting value of correlation coefficient, ANOVA test and p-value calculation.
	CO3	ChemDraw software in drawing of chemical structures and estimating structural properties.
	CO4	Scientific proposal writing and draft and its power point presentation.

Exp. 1	To understand the functions and to create mathematical formulas using Microsoft Excel worksheet.
Exp. 2	To learn the process of calculating the value of correlation coefficient using Microsoft Excel Worksheet.
Exp. 3	To learn process of preparing linear fittings of graphs and getting value of correlation coefficient using Origin software.
Exp. 4	To draw the Gas/liquid Chromatogram/UV/FTIR spectrum using Origin software.
Exp. 5	To understand functions ChemDraw software and lean to draw the structures of simple aliphatic and aromatic molecules.
Exp. 6	To learn the draw the structures of complex aliphatic and aromatic molecules using ChemDraw software.
Exp. 7	To learn the process of determining molecular formula, molecular weight and elemental percentage of chemical structures using ChemDraw software.
Exp. 8	Peak identification, analysis and to calculate the area under a curve (integration) for spectroscopy or chromatography data using Origin.
Exp. 9	Perform one-way ANOVA statistical approach for hypothesis testing and calculation of p-value.
Exp. 10	To learn research proposal writing and preparation of research presentation using MS Word/MS Power Point.

Reference Softwares:

- MS Office Software, Latest version, 2025.
- Origin Software, Latest version, 2025.
- ChemDraw Software, Latest version, 2025.