मौलाना आज़ाद राष्ट्रीय प्रौद्योगिकी संस्थान भोपाल

Maulana Azad National Institute of Technology Bhopal

(भारत सरकार, शिक्षा मंत्रालय के अधीन राष्ट्रीय महत्व का संस्थान)

(An Institution of National Importance under MoE, Govt. of India)

CURRICULUM PROFILE OF POST GRADUATE DEGREE

M.Sc. Chemistry

(Two years degree program 2024)

Programme Educational Objectives (PEOs) of M.Sc. Chemistry

Programme Educational Objectives (PEOs) of the programme M.Sc. Chemistry addresses wide aspects of Chemistry in line with the Department's vision and mission. These are:

PEO1	Develop in depth understanding of the various aspects of Chemistry and apply it for the betterment of society and environment.
PEO2	Develop laboratory skills and experimental protocols to prepare research-ready students for higher studies/industries.
PEO3	Explore interdisciplinary science and practice critical thinking for problem solving abilities with good interpersonal and communication skills.

Programme Outcomes (POs) and Program Specific Outcomes (PSOs)

PO1	Apply advanced concept of Physical, Inorganic, Organic and analytical Chemistry to solve practical problems.
PO2	Present theoretical concepts in chemistry and plan experiments to validate and reinforce these concepts.
PO3	Identify and propose research problems, execute experiments, collect and analyze data, and derive conclusions with consideration for future implications.
PO4	Practice proficiency in individual and team assignments effectively, demonstrate competence in both aspects.
PSO1	Apply the scientific knowledge to evaluate scientific literature and methodologies to design and execute solution to complex chemical problems.
PSO1	Develop human resources for scientific research and education in the area of chemical science.

M.SC. CHEMISTRY

Semester I

Course code	Title of the Course	L	T	P	Credit(s)
CY MS 511	**Physical Chemistry I** (Quantum Chemistry and Basic Spectroscopy)	3	-	-	3
CY MS 512	**Inorganic Chemistry I** (Coordination Chemistry and Reaction Mechanism)	3	-	-	3
CY MS 513	**Organic Chemistry I** (Basic stereochemistry and reaction mechanism)	3	-	-	3
CY MS 514	**Analytical Chemistry-I** (Principles, Practices And Applications)	3	-	-	3
	Elective- I	3	-	-	3
CY MS 515	**Physical Chemistry Lab I and Minor Project-I** *(Self learning)*	-	-	2	2
CY MS 516	**Inorganic Chemistry Lab I**	-	-	2	1
CY MS 517	**Organic Chemistry Lab I**	-	-	2	1
CY MS 518	**Seminar-I**	2	-	-	1
	Total Semester Credit				**20**

Communication Skill will be an Audit Course of 2 credits which will not be counted in SGPA/CGPA calculation.

Semester II

Course code	Title of the Course	L	T	P	Credit(s)
CY MS 521	**Physical Chemistry II** (Chemical Kinetics and Surface Chemistry)	3	-	-	3
CY MS 522	**Inorganic Chemistry II** (Main Group elements and Group Theory)	3	-	-	3
CY MS 523	**Organic Chemistry II** (Heterocyclic compounds and organic Reagents)	3	-	-	3
CY MS 524	**Chemistry of Materials**	3	-	-	3
	Elective –II	3	-	-	3
CY MS 525	**Physical Chemistry Lab II**	-	-	2	1
CY MS 526	**Inorganic Chemistry Lab II and Minor Project-II** *(Self learning)*	-	-	2	2
CY MS 527	**Organic Chemistry Lab II**	-	-	2	1
CY MS 528	**Seminar-II**			2	1
	Total Semester Credit				**20**

Semester III

Course code	Title of the Course	L	T	P	Credit(s)
CY MS 611	**Electrochemistry**	3	-	-	3
CY MS 612	**Organometallic Chemistry**	3	-	-	3
CY MS 613	**Organic Spectroscopy and Pericyclic Reactions**	3	-	-	3
CY MS 614	**Natural Products and Medicinal Chemistry**	3	-	-	3
	Elective –III	3	-	-	3
CY MS 615	**Physical Chemistry Lab III**	-	-	2	1
CY MS 616	**Inorganic Chemistry Lab III**	-	-	2	1
CY MS 617	**Organic Chemistry Lab III and Minor Project-III** *(Self learning)*	-	-	2	2
CY MS 618	**Seminar-III**	-	-	2	1
	Total Semester Credit				**20**

List of Elective-I		**List of Elective-II**	
CY MS 531	Mathematics in Chemistry	CY MS 551	Chemical and Statistical Thermodynamics
CY MS 532	Chemical Biology	CY MS 552	Optical Imaging and Ultrafast Spectroscopy
CY MS 533	Instrumental Methods of Analysis	CY MS 553	Research Methodology
List of Elective-III			
CY MS 654	Photophysical Chemistry		
CY MS 655	Synthon Approach in Organic Synthesis.		
CY MS 656	Radiations and Nuclear Chemistry		

Semester IV

Course code	Title of the Course	L	T	P	Credit(s)
CY MS 621	Project Dissertation and Presentation	-	-	40	20
	Total Semester Credit				**20**

Grand Total of the Course Credits =20+20+20+20= **80**

Name of Program	**M.Sc. Chemistry**
Name of Course	**Physical Chemistry I** (Quantum Chemistry and Basic Spectroscopy)
Course Code	**CY MS 511**
Core / Elective / Other	**Core**
Credit	**3**

Prerequisite:

1.	Understanding of fundamental algebra, calculus and classical mechanics will be useful.
2.	Basic idea of electromagnetic radiation, spectroscopy and atomic structure is required.

Course Outcomes: The students are expected to be able to:

1.	Describe the requirement of quantum mechanics in chemistry.
2.	Understand the application of wave functions to obtain information about the particle.
3.	Discuss the application of the Schrodinger equation in studying structure of H-atom and wave mechanics.
4	Understand the principles and applications of various spectroscopic techniques as discussed.
5.	Recall the selection rules for the spectroscopic techniques like Rotational, Vibrational etc.

Description of Contents in brief:

This course will cover basic aspects of quantum chemistry and their applications for simple systems, atomic and molecular structures. Second part of this course will cover basic principles of electronic, rotational, vibrational, NMR and ESR spectroscopy.

Detailed Syllabus:

1.	**Basic Principles of Quantum Chemistry:** Introduction; Operators and related theorems; Uncertainty principle; postulates; Properties of wave functions and related physical significance**;** Time-dependent and time-independent Schrödinger equations**;** energy Eigenvalue equation; Eigenvalues and Eigen functions equation of motion and constant of motion.
2.	**Application to Simple Systems and Approximation Methods:** Exactly solvable problems: Particle in a box, harmonic oscillator, rigid rotator, step potential and tunnelling, the hydrogen atom. Linear and non-linear variations method; applications (He atom and other simple systems). Rayleigh-Schrödinger time-independent perturbation theory with simple applications.
3.	**Fundamentals of atomic and molecular structure**: Wave nature of electron, atomic orbitals, shapes of s,p, and d orbitals, atomic structure, Bohr's model of H-atom, electron configuration, Pauli Principle, Hund's Rule, electronic configuration of elements, quantum numbers. Angular momentum: orbital angular momentum, spin angular momentum, total angular momenta. Spin and Pauli matrices. Term Symbols.

4.	**Chemical Bonding:** Many-electron atoms: Antisymmetric principle, orbital approximation, electron spin, Pauli exclusion principle, Slater determinants. Linear Variational method – secular determinant. Molecular Structure: Born-Oppenheimer approximation. Valence bond theory and linear combination of atomic orbitals – molecular orbital (LCAO-MO) theory. Hybrid orbitals. Applications of LCAO-MO theory for diatomic molecules. Molecular orbital theory (MOT) of homo and heteronuclear diatomic molecules. Hückel approximation and its applications to annular π-electron system.
5.	**Basic spectroscopy**: Atomic spectroscopy; Russell-Saunders coupling; Origin of selection rules. Rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Line broadening. Einstein's coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Nuclear magnetic resonance spectroscopy: gyromagnetic ratio; chemical shift, nuclear coupling.

List of Text Books:	
1.	Ira N. Levine, Quantum Chemistry, Prentice Hall
2.	R.K. Prasad, Quantum Chemistry, New Age International
3.	Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press
4.	D. L. Pavia, G.M. Lampman, G.S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5th ed. Cengage India, 2015.
List of Reference Books:	
1.	McQuarrie,D. A., (1983), Quantum Mechanics, 2nd Edition, University Science Books.
2.	Bernath,P. F., (2005), Spectra of Atoms and Molecules, 2nd Edition, Oxford University Press, London
3.	Banwell,C. N., (2010), Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw Hill, New Delhi

Lecture Plan (about 42 Lectures):

Lecture No.	Topic
	UNIT- I: Basic Principles of Quantum Chemistry
Lecture 1	An introduction to Quantum Chemistry, Energy quantization and black body radiation
Lecture 2	Uncertainty principle and other postulates
Lecture 3	Wave functions: physical significance and an introduction to Schrödinger equation
Lecture 4	Operators in Quantum Mechanics
Lecture 5-6	Observables and postulates of Quantum Mechanics.
Lecture 7-9	Time-dependent and time-independent Schrödinger equations Energy eigenvalue equation, Eigenvalues and Eigen functions equation of motion and constant of motion.
	UNIT-II: Application to Simple Systems and Approximation Methods
Lecture 1	Particle in a box: derivation and degeneracy
Lecture 2	Harmonic oscillator,

Lecture 3	Rigid rotator
Lecture 4	2-D confinement: Step potential; Introduction to tunneling.
Lecture 5	The hydrogen atom
Lecture 6	Linear and non-linear variations method
Lecture 7	Application of Schrodinger equations in He atom and other systems.
Lecture 8	Approximation Methods: Variation principle, Perturbation theory.
Lecture 9-10	Rayleigh-Schrödinger time-independent perturbation theory with simple applications.
	UNIT -III: Fundamentals of atomic and molecular structure
Lecture 1	Wave nature of electron, atomic orbitals, shapes of s,p, and d orbitals and energy.
Lecture 2	Atomic structure, Review Bohr's model of H-atom and Pauli Principle.
Lecture 3-4	Hund's Rule Atomic and molecular structure electron configuration
Lecture 5-6	Radial distribution functions and curves, electronic configuration of elements, quantum numbers.
Lecture 7	Angular momentum: orbital angular momentum, spin angular momentum, total angular momentum.
Lecture 8	Spin and Pauli matrices, Term Symbols.
	UNIT - IV: Chemical Bonding
Lecture 1	Many – electron atoms: Antisymmetric principle, orbital approximation
Lecture 2	Electron spin, Pauli exclusion principle, Slater determinants
Lecture 3	Linear Variational method: secular determinant
Lecture 4	Molecular Structure: Born-Oppenheimer approximation
Lecture 5	Valence bond theory
Lecture 6	Linear combination of atomic orbitals – molecular orbital (LCAO-MO) theory
Lecture 7	Hybrid orbitals. Applications of LCAO-MO theory for diatomic molecules
Lecture 8	Molecular orbital theory (MOT) of homo and heteronuclear diatomic molecules.
Lecture 9	Hückel approximation and its applications to annular π-electron system
	UNIT V: Basic Spectroscopy
Lecture 1	Atomic spectroscopy; Russell-Saunders coupling
Lecture 2	Origin of selection rules.
Lecture 3-4	Rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Line broadening
Lecture 5	Einstein's coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength
Lecture 6	Nuclear magnetic resonance spectroscopy: gyromagnetic ratio; chemical shift, nuclear coupling

Name of Program	**M.Sc. Chemistry**
Name of Course	**Physical Chemistry Lab I and Minor Project -I**
Course Code	**CY MS 515**
Core / Elective / Other	**Core**
Credit	**2**

Prerequisite:

1. Student should have a knowledge of glass wares used in chemical laboratory, basics of solution preparing, handling and lab safety.
2. Student should have knowledge of conductivity/ conductance, standard reduction/oxidation potential, equilibrium constant, neutralization reaction etc.
3. Skills of calculations and graphical representation of data /plotting graph will be useful.

Course Outcomes: The students are expected to be able to:

1. Construct Phase diagram for three-component system and analyse bimodal curve, plait points and tie lines.
2. Describe principles behind the experiments e.g. Viscometry, pH metry, Potentiometry, Refractometry performed in the laboratory and their applications.
3. Classify different types of potentiometric titrations based on different experiments.
4. Interpret the experimental results obtained by using Viscometry, pH metry, Potentiometry, Refractometry.

Description of Contents in brief:

In this course student will learn about phase diagrams, transition temperature, viscosity and viscosity index, volumetric analysis based on potentiometer and pH metry, refractive index of solutions mixers, etc.

Detailed Syllabus:

1. **Transition temperature and Phase Diagram:**
   Transition temperature of hydrated salts and two/three-component phase diagrams.
2. **Viscometry:**
   Determine the viscosity of liquids using viscometer and study the variation with concentration/temperature.
3. **Adsorption Isotherm:**
   Determination of adsorption of given adsorbate by adsorbant and study adsorption isotherm.
4. **pH-metry**
   Determine the strength of weak/strong acid by pH-metric titration with weak/strong base.
5. **Potentiometric**:
   To determine the standard electrode potential of the ferrous ferric system by titrating ferrous ammonium sulphate against potassium dichromate and estimation of the solubility product and dissociation constant of the given substance.
7. **Refractometry:**
   Determine the refractive index, specific and molar refraction of simple organic liquids.

List of Text Books:	
1.	J. B. Yadav. "Advanced Practical Physical Chemistry", Krishna's Educational Publishers; 13th Edition, 2011.
2.	Gurdeep Raj. "Advanced Physical Chemistry"; Krishna's Educational Publishers, 2014.
3.	Renu, Gupta. "Practical Physical Chemistry"; New Age International (P) ltd; 1st edition; 2017.
List of Reference Books:	
1.	Khosla, B.D.; Garg, V.C. & Gulati, "A. Senior Practical Physical Chemistry,R Chand Co.: New Delhi, 2011.
2.	Garland, C.W.; Nilber, J.w. & Shoemaker, D.P. "Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York, 2009.
3.	Athawale, V.D. & Mathur, P. "Experimental Physical Chemistry New Age International: New Delhi, 2007

Lecture Plan (about 24 Lectures):

Lecture No.	Topic
Lecture 1-2	Orientation of lab (Do's and Don'ts), Safety measures.
Lecture 3-4	Determination of the Transition Temperature of hydrated salts: $CaCl_2$ and $NaSO_4.10H_2O$ thermometrically and/or by solubility.
Lecture 5-6	To draw the phase diagram of the binary system: diphenyl amine and α-naphthol and find the eutectic temperature.
Lecture 7-8	Estimate the variation in viscosity with concertation/temperature for a given (glycerol) solution.
Lecture 9-10	Determine the composition of the given mixture consisting of two miscible liquids viscometrically.
Lecture 11-12	To determine the adsorption of aqueous acetic acid by activated charcoal and to study the adsorption isotherm.
Lecture 13-14	Determination of the strength of the acid (strong/weak) by pH metric titrations with base (strong/weak)
Lecture 15-16	Potentiometric titration of $K_2Cr_2O_7$ & Ferrous Ammonium Sulphate and comparison with volumetric titrations.
Lecture 17-18	Determine the Solubility Product of $BaSO_4$ Potentiometrically.
Lecture 19-20	Determine the Dissociation constant of di-basic acid (oxalic acid) Potentiometrically.
Lecture 21-22	Determine the refractive index, Specific & Molar Refraction of given percentage of solutions (Toluene/Acetone).
Lecture 23-24	**Physical Chemistry Lab I and Minor Project-I** *(Self learning)*

Name of Program	**M.Sc. Chemistry**
Name of Course	**Physical Chemistry II** (Chemical Kinetics and Surface Chemistry)
Course Code	**CY MS 521**
Core / Elective / Other	**Core**
Credit	**3**

Prerequisite:	
1.	Student should have knowledge of basic chemistry and related terminologies.
2.	An understanding of basic mathematics such as algebra, calculus and functions such as exponential and logarithm will be useful.
Course Outcomes: The students are expected to be able to:	
1.	Describe chemical rate laws, molecularity and order using the given information.
2.	Classify different theories given for chemical kinetics.
3.	State difference between kinetically and thermodynamically controlled reactions.
4.	Understand fundamentals and applications of surface chemistry.
Description of Contents in brief:	
First part of this course will cover different aspects of chemical kinetics such as molecularity order, rate constants, theories for determining rate constant and examples including polymerization and catalysis. Second part of the course covers various topics of surface chemistry, colloids, macromolecules and adsorption phenomenon.	
Detailed Syllabus:	
1.	**Chemical Kinetics-I**: Steady-state approximation. Mechanisms of complex reactions. Empirical rate laws and temperature dependence; Methods of determining rate laws, collision theory reaction rates, steric factor, Arrhenius theory and activated complex theory, ionic reactions and kinetic salt effects, steady-state kinetics, kinetic and thermodynamic control of reactions. Comparison of collision and activated complex theory.
2.	**Chemical Kinetics-II**: Unimolecular reaction theories including Eyring equation and Lindermaan Hinshelwood and Rice-Ramsperger-Kassel-Markus (RRK and RRKM). Dynamic chain reactions and photochemical reactions. Kinetic isotope effects. Fast reaction kinetics: relaxation and flow methods. Kinetics of photochemical and photophysical processes Kinetics of polymerization and enzyme catalysis. Kinetics of One-Enzyme-One Substrate reactions: Michaelis-Menten Mechanism.
3.	**Surfactants and Interfacial Phenomena:** Classification, micellization, C.M.C and its determination. Shape and structure of micelles, effect of additives on micellization, thermodynamics of micellization, solubilization and applications, effect of electrolytes on solubilization. Macro and micro emulsions, dispersion and aggregation of solids by surfactants.
4.	**Colloids and Macromolecules:** Origin of the charges, electro-kinetic phenomena, electrophoresis, electroosmosis, sedimentation and streaming potential. The concept of electrical double layer and various models to explain its structure and properties, Smoluchowski theory of kinetics of coagulation and distribution of colloids aggregates. Concepts of mass and number average molecular weights, methods of determining molecular weights (osmometry, viscometry, diffusion and light scattering method),

	sedimentation, fractional properties of macromolecules, statistical distribution of end-to-end dimension, calculation of average dimension of various chain structures.
5.	**Adsorption Phenomenon:** Gibbs adsorption equation, Langmuir adsorption isotherm and its derivation for non-dissociative and dissociative adsorption, BET adsorption isotherm, its derivation and applications. Surface catalysis: Langmuir-Hinshelwood mechanism.
List of Text Books:	
1.	P.W. Atkins, Physical Chemistry, ELBS
2.	K.J. Laidller, Chemical Kinetics , 2013, Chemical Kinetics, Pearson.
3.	Puri, Sharma, Pathaniya, Principles of Physical Chemistry, Vishal Publications
List of Reference Books:	
1.	Silbey, R. J.; Alberty, R. A. &Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
2.	Chorkendorff, Ib. &Niemantsverdriet, J. W. Concepts of Modern Catalysis and Kinetics Wiley-VCH (2003).

Lecture Plan (about 42 Lectures):

Lecture No.	Topic
	Chemical Kinetics-I
Lecture 1	Steady state approximation. Mechanisms of complex reactions
Lecture 2	Empirical rate laws and temperature dependence; Methods of determining rate laws
Lecture 3	Collision theory reaction rates, steric factor
Lecture 4-5	Arrhenius theory and activated complex theory
Lecture 6	Ionic reactions and kinetic salt effects
Lecture 7	Steady state kinetics, kinetic and thermodynamic control of reactions
Lecture 8	Comparison of collision and activated complex theory
	Chemical Kinetics-II
Lecture 1-3	Unimolecular reaction theories: Eyring equation and Lindermaan Hinshelwood
Lecture 4-5	Unimolecular reaction theories: Rice-Ramsperger-Kassel-Markus (RRK and RRKM)
Lecture 6	Dynamic chain reactions and photochemical reactions. Kinetic isotope effects
Lecture 7	Fast reaction kinetics: relaxation and flow methods
Lecture 8	Kinetics of photochemical and photophysical processes
Lecture 9	Kinetics of polymerization and enzyme catalysis
Lecture 10	Kinetics of One-Enzyme-One Substrate reactions: Michaelis-Menten Mechanism
	UNIT III: Surfactants and Interfacial Phenomena
Lecture 1	Introduction and Classification
Lecture 2	Micellization
Lecture 3-4	C.M.C. and its determination
Lecture 5	Shape and structure of micelles
Lecture 6	Effect of additives on micellization, thermodynamics of micellization
Lecture 7	Solubilization and applications

Lecture 8 Lecture 9 Lecture 10	Effect of electrolytes on solubilization Macro and micro emulsions Dispersion and aggregation of solids by surfactants
	UNIT IV: Colloids and Macromolecules
Lecture 1 Lecture 2 Lecture 3 Lecture 4 Lecture 5-6 Lecture 7-8	Origin of the charges Electro-kinetic phenomena Electrophoresis, electroosmosis Sedimentation and streaming potential The concept of electrical double layer and various models to explain its structure and properties Smoluchowski theory of kinetics of coagulation and distribution of colloids aggregates.
	UNIT V: Adsorption Phenomenon
Lecture 1 Lecture 2-3 Lecture 4-5 Lecture 6	Gibbs adsorption equation Langmuir adsorption isotherm and its derivation for non-dissociative and dissociative adsorption BET adsorption isotherm, its derivation and applications Surface catalysis: Langmuir-Hinshelwood mechanism

Name of Program	**M.Sc. Chemistry**
Name of Course	**Chemistry of Materials**
Course Code	**CY MS 524**
Core / Elective / Other	**Core**
Credit	**3**
Prerequisite:	
	NIL
Course Outcomes: The students are expected to be able to:	
1.	Review structural aspects in material science, properties, and basic method of characterization of solids.
2.	Compare electronic and magnetic properties of bulk materials with nanomaterials.
3.	Classify nanomaterials type, synthesis methods and their applications.
4.	Identify Impact of nanomaterials on environment and human health.
Description of Contents in brief:	
This course will cover structural aspects, properties and applications of materials in their bulk and nanomaterial sizes useful in interdisciplinary science and engineering. Students will advance their knowledge in nanomaterials synthesis, applications and sustainable nanotechnology.	
Detailed Syllabus:	
1.	**Structures and properties of solids**: Introduction, crystalline and amorphous solids, Unit cell, Bravais lattices, structure of NaCl and KCl, point defects – Frenkel, Schottky defects and non-stoichiometric defects. X-ray Diffraction: Generation and production of X-ray, Scattering, Braggs's law, Laue equation, and structure factor, systematic absences, Ordered and disordered of solid.
2.	**Electrical and magnetic properties**: Electronic structure of solids: Band theory of solid. Optical, mechanical and magnetic properties of ordered and disordered materials & their applications. Conductors, variation of conductivity with temperature, semiconductors, p and n types, photo voltaic cell. Piezoelectric and pyro-electrics. Diamagnetic, paramagnetic, anti-ferromagnetic, ferro- and ferrimagnetic materials. Magnetic susceptibility, variation with temperature – Curie-Wiess law, Curie temperature and Neel temperature. Permanent and temporary magnets.
3.	**Nanomaterial**: Introduction, Nanotechnology, classification & evolution of Nanotechnology, Implications for Physics, Chemistry, Biology and Engineering. Nanomaterials: Introduction & properties of nanomaterials, size& shape – 1D, 2D, 3D viz. nanoparticles, nanowire, nanocluster, quantum dot; Information-Driven Nanoassembly, Energetics, Topdown and bottom-up approach for building nanomaterials.
4.	**Synthesis and Applications**: Top to down and Bottom-up approach, Chemical route of synthesis, sol-gel, solvothermal synthesis, Green synthesis-and Microwave techniques, electrochemical, photochemical synthesis. Nanosemiconductor, nanopolymer, nanocomposite applications. Composite materials: Introduction, types of fillers and matrix, classification of composite materials based on distribution and nature of fillers. Particulate and fibrous metal/non-metal composites, polymer nanocomposites and their applications.

5.	**Sustainable Nanotechnology**: Application of industrial ecology to nanotechnology, Impacts of nanomaterials to environment, environmental and health impacts of nano materials, toxicological threats, eco-toxicology, exposure to nano particles – biological damage, threat posed by nano materials to humans, environmental reconnaissance and surveillance.
List of Text Books:	
1.	B. D. Cullity and S. R. Stock, (2014), Elements of X-ray diffraction, 3rd edition, Pearson
2.	West, A.R., (2015) Solid State Chemistry and Its Applications, 2nd edition, John Wiley & Sons.
3.	Lesley E Smart and Elaine E Moore, (2005), Solid State Chemistry: An Introduction, 3rd Edition, Taylor and Francis
4.	Cao, Guozhong. Nanostructures & Nanomaterials: Synthesis, Properties & Applications. Singapore, Imperial College Press, 2004.
5.	The Chemistry of Nanomaterials: Synthesis, Properties and Applications. Germany, Wiley, 2006.
6.	Kalarikkal, Nandakumar, and Raneesh, B. Advanced Nanomaterials: Synthesis, Properties, and Applications. United States, Apple Academic Press, 2014.
List of Reference Books:	
1.	Cheetham, A.K. and Day, P., (1997), Solid State Chemistry Compounds, 2nd Edition, Clarendon Press, Oxford
2	T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, Tata McGraw-Hill Publishing Company Limited NEW DELHI, 2007
3.	JRC-REACH implementation project substance identification of nanomaterials (RIP-oN 1) Institute for Health and Consumer Protection (2011)
4.	Harry R. Allcock, (2008), Introduction to Materials Chemistry, 1st Edition, Wiley.
5.	C N R Rao and J Gopalkrishnan, (2004) New Directions in Solid State Chemistry, 2nd Edition, Cambridge
6.	A.R. Koehler, C. Som Human and Ecological Risk Assessment, 14 (2008),

Lecture Plan (about 42 Lectures):

Lecture No.	Topic
	UNIT-I: Structures and properties of solids
Lecture 1	Introduction to Crystalline and amorphous solids
Lecture 2	Unit cell, Bravais lattices, Structure of NaCl and KCl,
Lecture 3	Point defects – Frenkel, Schottky defects and non-stoichiometric defects.
Lecture 4-5	X-ray Diffraction: Generation and production of X-ray, Scattering, Braggs's law,
Lecture 6-9	Laue equation, and structure factor, systematic absences, Ordered and disordered of solid.
	UNIT-II: Electrical and Magnetic Properties of solids
Lecture 1	Electronic structure of solids: Band theory of solid.
Lecture 2	Optical, mechanical and magnetic properties of ordered and disordered materials & their applications.
Lecture 3	Continued…
Lecture 4	Conductors, variation of conductivity with temperature. Semiconductors, p
Lecture 5	and n types, photo voltaic cell. Piezoelectric and pyro-electrics.
Lecture 6	Diamagnetic, paramagnetic, anti-ferromagnetic, ferro- and ferrimagnetic
Lecture 7-9	materials. Magnetic susceptibility, variation with temperature – Curie-Wiess law, Curie temperature and Neel temperature. Permanent and temporary magnets.

	UNIT-III: Nano-materials Introduction
Lecture 1-2 Lecture 3-4 Lecture 5-8	Introduction to Nanotechnology and Nanomaterials, evolution of Nanotechnology Nanomaterials classifications, size, shape – 1D, 2D, 3D origin etc. Classification and properties of nanomaterials, viz. nanoparticles, nanowire, nanocluster, quantum dot; Information-Driven Nanoassembly, Energetics.
	UNIT-IV: Synthesis and Applications
Lecture 1 Lecture 2 Lecture 3-4 Lecture 5 Lecture 6-7 Lecture 8 -10	Top to down and Bottom up approach, comparison Chemical route of synthesis, sol-gel, solvothermal synthesis, Green synthesis and Microwave techniques, electrochemical, photochemical synthesis. Nano semiconductor- synthesis, explanation with examples in metal oxide, perovskite, etc. Challenges for preparation and property. Nanopolymer, nanocomposite& Nano-electronic devices - Applications Composite materials, classification of composite materials based on distribution and nature of fillers. Particulate and fibrous metal/non-metal composites, polymer Nano-composites and their applications.
	UNIT-V: Sustainable Nanotechnology
Lecture 1 -2 Lecture 3-4 Lecture 5-8	Sustainable nanotechnology –Introduction, biomedical, food and agriculture industry. Nano manufacturing – toxicological threads to animal and environment Risk assessment to environment due to any new material nanomaterials

Name of Program	**M.Sc. Chemistry**
Name of Course	**Physical Chemistry Lab II**
Course Code	**CY MS 525**
Core / Elective / Other	**Laboratory**
Credit	**1**

Prerequisite:

1. Basic knowledge of handling of solutions and safety measures.
2. Student should have a basic conceptual knowledge of – conductivity, cell potentials, equilibrium constant, dissociation constant, solubility product and neutralization.
3. Skills of calculations and graphical representation of data /plotting graph will be useful.

Course Outcomes: The students are expected to be able to:

1. Verify the fundamental concepts using different analytical experiments such as Polarimetry, Conductometry and Calorimetry.
2. Determine rate orders, rotation angles of light passing through the solution, Standard electrode potential for given chemical reactions/solutions.
3. Establish the relation between solubility & solubility product of $PbSO_4$& $BaSO_4$ using conductometer.
4. Estimate the heat of neutralization of strong acid and strong base using calorimeter.

Description of Contents in brief:

This laboratory course covers various experimental methods such as volumetric analysis bases on conductometer and study of reaction kinetics, measurement of angel of rotation using Polarimeter.

Detailed Syllabus:

1. **Viscometry:**
   Determination of molecular weight using Viscometry**.**
2. **Chemical kinetics**:
   Determination of rate constant, order of reaction, study of influence of the ionic strength and dissolution of the given substance.
3. **Calorimetry**:
   Heat of neutralization of strong/weak acid with a strong/weak base.
4. **Conductometry**:
   Determine the basicity of mono-, di-, and tri- basic acids and critical micelle concentration (CMC) of a surfactant (sodium lauryl sulphate) by conductivity method.
5. **Partition law and Salt effect:**
   Determine the distribution coefficient/ partition coefficient in the organic solvents and water at room temperature. Effect of salt addition on critical solution temperature
6. **Polarimetry**:
   Study the kinetics of inversion of cane sugar (sucrose) in presence of an acid/ determination of relative strength of acids by the study of inversion of sucrose.

List of Text Books:

1.	J. B. Yadav. "Advanced Practical Physical Chemistry", Krishna's Educational Publishers; 13th Edition, 2011.
2.	Gurdeep Raj. "Advanced Physical Chemistry"; Krishna's Educational Publishers, 2014.
3.	Renu, Gupta. "Practical Physical Chemistry"; New Age International (P) ltd; 1st edition; 2017.
4.	A.M James, Goel P.H. Advanced Practical Physical Chemistry.
5.	Khosla, B.D.; Garg, V.C. & Gulati, "A. Senior Practical Physical Chemistry,R Chand Co.: New Delhi, 2011.
List of Reference Books:	
1.	Garland, C.W.; Nilber, J.w. & Shoemaker, D.P. "Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York, 2009.
2.	Athawale, V.D. &Mathur, P. "Experimental Physical Chemistry New Age International: New Delhi, 2007
3.	B.P. Levitt, Longman; "Findley's Practical Physical Chemistry".

Lecture Plan (about 16 Lectures):

Lecture No.	Topic
Lecture 1	Orientation of lab (Do's and Don'ts)
Lecture 2-3	Determine the molecular weight of polymers (e.g. PVA and PS) using viscosity.
Lecture 4-5	To study the reaction kinetics of Potassium and KI and to determine rate constant; study of influence of ionic strength. OR To determine the order of the reaction between potassium persulphate and potassium iodide by fractional change method.
Lecture 5-6	Calorimetrically: Heat of neutralization of acid (HCl /CH_3COOH) with a strong base (NaOH).
Lecture 7-8	Determine the basicity of mono-, di- & tri- basic acids conductometrically/
Lecture 9-10	Conductometric titrations involving weak/strong acid and strong/weak base.
Lecture 11-12	Determine the CMC of the given surfactant using conductivity method.
Lecture 13-14	Determine the distribution coefficient of Iodine between organic solvents and water at room temperature.
Lecture 15-16	Determine the partition coefficient of benzoic acid between water and benzene at RT and molecular state of benzoic acid in benzene.
Lecture 15-16	To study the kinetics of inversion of cane sugar (sucrose) in presence of an acid/ relative strength of acids by the study of inversion of sucrose.

Name of Program	**M.Sc. Chemistry**
Name of Course	**Electrochemistry**
Course Code	**CY MS 611**
Core / Elective / Other	**Core**
Credit	**3**

Prerequisite:

1. Student understands of basic chemistry such as chemical kinetics, chemical thermodynamics are desirable.
2. An understanding of basic components of electrochemistry will be useful.

Course Outcomes: The students are expected to be able to:

1. Explain fundamental aspects of electrochemical reaction in terms of thermodynamics, kinetics and mass transport.
2. Classify electrolytic conduction and related treatment such as Debye-Huckel-Onsager, Kohlrausch's law and its applications.
3. Differentiate conductometric and potentiometric titrations.
4. Explain measuring principle of fundamental electrochemical methods such as cyclic voltammetry.
5. Recognize the practical usage of electrochemical technology in our life.

Description of Contents in brief:

This course focuses on the electrochemical aspects of the reactions, electrochemical processes and methods in electrochemistry. In this course student will advance their knowledge and concepts of electrochemistry to understand principles of typical electrochemical devices and explain electrochemical phenomena in terms of redox chemistry.

Detailed Syllabus:

1. **Introduction to Electrochemistry**: Nernst equation, redox systems, electrochemical cells; electrode kinetics, dynamic electrochemistry, the Butler-Volmer and Tafel equations, over-potentials. Kinetically and mass transport controlled electrochemical processes. Mass transport: migration, convection and diffusion.
2. **Equilibrium Electrochemistry**: Debye-Huckel-Onsager treatment and its extension, electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.
3. **Solid state electrochemistry**: Ion conducting polymers, electronically conducting polymers and redox polymers. Electrochemical double layer, Potentiostatic and Galvanostatic methods.
4. **Cyclic Voltammetry and Chronoamperometry**: Theory, principle, basics of Cyclic Voltammetry, Cyclic voltammogram. Applications of cyclic voltammetry: Qualitative and quantitative analysis; pulse voltammetry. Chronoamperometry: Potentiostatic and Galvanostatic Chronoamperometry, Charge discharge cycle of rechargeable battery from Chronoamperometry, Use of chemical and biosensors in environmental pollutant detection.
5. **Electrochemical techniques:** coupled to in situ techniques providing structural information. Surface confined electrochemical processes. Electro polymerization homogeneous and heterogeneous electrocatalysis, electrochemical processes coupled to chemical steps. Nanostructured and surface modified electrodes, comparisons of

	batteries, fuel cells and supercapacitors. Electrochemical processes of particular relevance to energy conversion, energy and power densities.
List of Text Books:	
1.	Antropov, Lev Ivanovich. Theoretical Electrochemistry. United States, International Law & Taxation Publishers, 2001.
2.	Bockris, John O'M., and Reddy, AmulyaK.N.. Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science. Germany, Springer US, 2007.
3.	Reddy, Amulya K.N., and Bockris, John O'M.. Modern Electrochemistry: An Introduction to an Interdisciplinary Area. United States, Springer US, 2012.
4.	Sobkowiak, Andrzej, et al. Electrochemistry for Chemists. United Kingdom, Wiley, 1995.
List of Reference Books:	
1.	Electrochemical methods: fundamentals and applications. India, Wiley India Limited, 2004.
2.	Transient Techniques in Electrochemistry. United States, Springer US, 2011.
3.	Laboratory Techniques in Electroanalytical Chemistry, Revised and Expanded. United States, CRC Press, 2018.
4.	Greff, R, et al. Instrumental Methods in Electrochemistry. United Kingdom, Elsevier Science, 2001.

Lecture Plan (about 42 Lectures):

Lecture No.	Topic
	UNIT – I: Introduction to Electrochemistry
Lecture 1-2	Introduction to electrochemistry and review fundamentals.
Lecture 3-4	Advanced Aspects of Nernst Equation, redox systems, electrochemical cells;
Lecture5-6	Electrode kinetics, dynamic electrochemistry, Butler-Volmer and Tafel equations, over-potentials.
Lecture7-8	Kinetically and mass transport controlled electrochemical processes. Mass transport: migration, convection and diffusion. Numerical problems/ questions.
	UNIT – II: Equilibrium Electrochemistry
Lecture 1	Debye-Huckel-Onsager treatment and its extension,
Lecture 2	Electrolytic conductance – Kohlrausch's law and its applications;
Lecture 3	Ionicequilibria; conductometric and potentiometric titrations.
Lecture 4	conductometric and potentiometric titrations
Lecture 5	conductometric and potentiometric titrations
Lecture 6	Numerical problems/ questions.
Lecture 7	Numerical problems/ questions.
	UNIT – III: Solid State Electrochemistry
Lecture 1	Background on Solid state electrochemistry
Lecture 2	Ion conducting polymers, electronically conducting polymers
Lecture 3	Redox polymers. Defect Chemistry in Solid State Electrochemistry
Lecture 4	Defect Chemistry in Solid State Electrochemistry
Lecture 5	Electrochemical double layer,
Lecture 6	Potentiostatic and Galvanostatic methods
Lecture 7-8	Continued…
,/	**UNIT – IV: Cyclic Voltammetry and Chronoamperometry**
Lecture 1	Cyclic Voltammetry, Cyclic voltammogram.
Lecture 2	

Lecture 3 Lecture 4 Lecture 5 Lecture 6 Lecture 7 Lecture 8-9	Applications of cyclic voltammetry: Qualitative and quantitative analysis; Pulse voltammetry. Continued… Chronoamperometry: Potentiostatic and Galvanostatic Chronoamperometry, Continued… Charge discharge cycle of rechargeable battery from Chronoamperometry. Continued…
	UNIT - 5 Electrochemical techniques
Lecture 1 Lecture 2 Lecture 3 Lecture 4 Lecture 5 Lecture 6 Lecture 7 Lecture 8 Lecture 9-10	Electrochemical techniques coupled to in situ techniques providing structural information. Continued… Surface confined electrochemical processes. Electro polymerization homogeneous and heterogeneous electrocatalysis, Electrochemical processes coupled to chemical steps. Continued… Nanostructured and surface modified electrodes, comparisons of batteries, fuel cells and supercapacitors. Continued… Electrochemical processes of particular relevance to energy conversion, energy and power densities. Continued…

Name of Program	**M.Sc. Chemistry**
Name of Course	**Physical chemistry lab III**
Course Code	**CY MS 615**
Core / Elective / Other	**Core**
Credit	**1**

Prerequisite:

1.	Student should have a basic knowledge of glass wares, solution preparing, and handling and safety measures.
2.	Basic concept– spectroscopy, electrochemistry is desirable.
3.	Skills of calculations and graphical representation of data /plotting graph will be useful.

Course Outcomes: The students are expected to be able to:

1.	State the validity of Onsager Equation using conductometer.
2.	Apply spectroscopic procedures/techniques for Beer's Law and dissociation constant.
3.	Illustrate absorption and emission measurements to calculate relative quantum yield.
4.	Correlate surface tension with atomic parachors of C,H and O.

Description of Contents in brief:

This laboratory course covers various experimental methods to determine standard electrode potential, solubility, and equivalent conductance etc. of electrolytic solutions. Spectroscopic methods will be used for absorption/emission measurement of fluorescent dye and dissociation constant of methyl red.

Detailed Syllabus:

1.	**Conductometry:** 1. Determination of the equivalent conductance of weak acid (benzoic and acetic acid) at several concentrations and the dissociation constant of the acid. 2. Determination of the equivalent conductance of strong electrolytes such as HCl, KCl, KNO_3 and NaCl and the validity of Onsager equation
2.	**Colorimetry and Spectroscopy:** 1. Colorimetric Iron/Copper analysis. 2. Verification of Beer's Law using coloured solutions. 3. Steady state absorption and emission measurements of fluorescent dye. 4. Dissociation constant of methyl red by spectroscopic methods at different dilutions.
3.	**Surface Tension**: 1. Determination of surface Tension by stalagmometer. 2. Determination of surface Tension by solubility method.

List of Text Books:

1.	J. B. Yadav. "Advanced Practical Physical Chemistry", Krishna's Educational Publishers; 13th Edition, 2011.
2.	Gurdeep Raj. "Advanced Physical Chemistry"; Krishna's Educational Publishers, 2014.
3.	Renu, Gupta. "Practical Physical Chemistry"; New Age International (P) ltd; 1st edition; 2017.
4.	Khosla, B.D.; Garg, V.C. & Gulati, "A. Senior Practical Physical Chemistry,R Chand Co.: New Delhi, 2011.

List of Reference Books:

1.	Garland, C.W.; Nilber, J.w. & Shoemaker, D.P. "Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York, 2009.
2.	Athawale, V.D. & Mathur, P. "Experimental Physical Chemistry New Age International: New Delhi, 2007
3.	B.P. Levitt, Longman; "Findley's Practical Physical Chemistry".

Lecture Plan (about 16 Lectures):

Lecture No.	**Topic**
Lecture 1-2	To determine equivalent conductance of strong electrolytes (HCl, KCl, KNO3, NaCl) validate Onsager equation using conductometer.
Lecture 3-4	Verification of Beer's Law using colored (organic/inorganic) solutions.
Lecture 5-6	Colorimetric analysis of Iron/Copper.
Lecture 7-8	Determine quantum yield by using steady state fluorescence absorption measurements.
Lecture 9-10	Dissociation constant of methyl red / given organic dye by spectroscopic methods at different dilutions.
Lecture 11-12	Determination of surface tension of MeOH/EtOH and n-hexane at RT and calculate the atomic parachor of C, H and O.

Name of the Program	**M.Sc. Chemistry**
Name of Course	**Mathematics in Chemistry**
Course Code	**CY MS 531**
Core/ Elective/ Other	**Elective**
Credit	**3**
Prerequisite	
1.	Basic knowledge of elementary differentiation, integration, matrices and probability calculus.
Course Outcome: The students are expected to be able to	
1.	Knowledge and understand basic mathematics used in chemistry.
2.	Knowledge of interpreting different spectra used in chemical calculations.
Description of Content in brief	
	Vectors and their applications, Calculus, Increasing and decreasing functions, Probability.
Detailed Syllabus:	
1.	**Vectors and their applications**: Matrix – types of matrices e.g. Hermetian and skew Hermitian. Solution of any system of linear equation – matrix & cramer rule method. Characteristic equation of a square matrix, eigen value and eigen vector;
2.	**Calculus**: Application of differentiation equation: Derivative as a slope of the tangent, derivative as a rate measure-velocity and acceleration.
3.	**Increasing and decreasing functions**: Maxima and minima-second derivative test-point of inflections-problems restricted to polynomial; Integrations: application to areas of plane curves;
4.	**Probability:** Review of permutations and combinations, probability and addition theorem for mutually exclusive events and multiplication theorem for independent events. Curve fitting-Method of least squares.
List of Books	
1.	Calculations In Chemistry An Introduction, 2nd Edition by Donald J. Dahm , Eric A. Nelson, Ww Norton & Co. 2017.
2.	Mathematics for chemists, P. G. Francis, Springer, 2011.
3.	Maths for Chemists by Doggett Graham, Volume 1, ISBN: 9780854046775, 9780854046775.
4.	Numerical Methods by Goel, Atul, 2019
Lecture plan: About 30 lectures	
Lecture No.	**Topic**
Unit I: Vectors and their applications	
Lecture 1	Matrix – types of matrices e.g. Hermitian and skew Hermitian.
Lecture 2	Continued
Lecture 3	Solution of any system of linear equation – matrix & Cramer's rule method.
Lecture 4	Continued
Lecture 5	Characteristic equation of a square matrix, eigen value and eigen vector.
Lecture 6	Continued
Lecture 7	Continued
Unit II: Calculus	
Lecture 1	Application of differentiation equation: Derivative as a slope of the tangent.

Lecture2	Continued
Lecture 3	Problems based on differentiation
Lecture4	Continued
Lecture 5	Derivative as a rate measure-velocity and acceleration.
Lecture 6	Continued
Lecture 7	Continued
Unit III: Increasing and decreasing functions	
Lecture 1	Maxima and minima-second derivative test-point of inflections-problems restricted to polynomial
Lecture 2	Continued
Lecture 3	Continued
Lecture 4	Integrations: application to areas of plane curves.
Lecture 5	Continued
Lecture 6	Continued
Lecture 7	Continued
Unit IV: Probability	
Lecture 1	Review of permutations and combinations
Lecture 2	Continued
Lecture 3	Probability and addition theorem for mutually exclusive events
Lecture 4	Continued
Lecture 5	Continued
Lecture 6	Multiplication theorem for independent events.
Lecture 7	Continued
Lecture 8	Curve fitting-Method of least squares.
Lecture 9	Continued

Name of Program	**M.Sc. Chemistry**
Name of Course	**Chemical Biology**
Course Code	**CY MS 532**
Core / Elective / Other	**Elective**
Credit	**3**

Prerequisite:	
1.	Student should have basic knowledge and understanding of basic Chemistry.
2.	An understanding of cell structure will be useful.
3.	This class is accessible to *those students* who does not study biological sciences at graduation level.
Course Outcomes: The students are expected to be able to:	
1.	Describe basic biomolecules like carbohydrate fatty acids proteins amino acids etc.
2.	Classify different types of terpenes and alkaloids and their uses.
3.	Interpret the structure of haemoglobin and myoglobin and their oxygen binding capacity.
4.	Understand different type of photosystem their uses and the electron transport mechanism.
5.	Restate the importance of Biological N_2 fixation.
Description of Contents in brief:	
This course consists of three parts: Bio inorganic Chemistry, Bio organic Chemistry and Bio physical Chemistry. The chemistry in biological system is briefly covered in this course.	
Detailed Syllabus:	
1.	**Bioinorganic Chemistry**: Ion (Na^+ and K^+) transport, photosystems, porphyrins, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc.
2.	**Biophysical Chemistry**: Interactions in Biological systems, Conformational properties of polypeptides, primary and secondary structure α-helix, β-sheet structures etc., tertiary and quaternary structure, structural features of membrane proteins, kinetics and thermodynamics of protein folding unfolding.
3.	**Bio organic chemistry**: Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids etc.
List of Text Books:	
1.	Cantor, Charles R., and Schimmel, Paul R.. Biophysical Chemistry Part I and II. Egypt, W. H. Freeman, 1980.C.R.
2.	Finkelstein, Alexei V., and Ptitsyn, Oleg. Protein Physics: A Course of Lectures. Netherlands, Elsevier Science, 2016
3.	Kuriyan, John, et al. The Molecules of Life: Physical and Chemical Principles. United Kingdom, Garland Science, Taylor & Francis Group, 2013.
4.	Principles of Bioinorganic Chemistry. S. J. Lippard, J. M. Berg. University Science Books, 1994
List of Reference Books:	
1.	Lehninger, Albert L., et al. Lehninger principles of biochemistry. United Kingdom, W. H. Freeman, 2008.
2.	Glaser, Roland. Biophysics: An Introduction. Germany, Springer Berlin Heidelberg, 2012.
3.	Gray, Professor Harry, et al. Biological Inorganic Chemistry: Structure and Reactivity. United Kingdom, University Science Books, 2007.

4.	Begley, Tadhg, et al. The Organic Chemistry of Biological Pathways. Belgium, Roberts and Company Publishers, 2005.

Lecture Plan (about 30 Lectures):

Lecture No.	Topic
	UNIT - 1 Bioinorganic Chemistry
Lecture 1-2	Structure and Function Membrane (lipid bilayer), Structure and Function of the Na,K-ATPase.
Lecture 3-4	Ion (Na+ and K+) transport: The Sodium-Potassium Pump, Active & Passive Mechanism of Na-K transport, Electrochemical Gradient
Lecture 5-6	Photosystems, introduction, Chlorophylls, PS-I & II and differences, Cyclic & non cyclic electron flow in PS,
Lecture 7	Photosystems, Light interaction to generate ATP & NADPH,
Lecture 8	Porphyrins: introduction and structures of Hb, Myoglobin, Cytochrome, Catalase, Peroxidase etc.
Lecture 9-10	Binding of Oxygen with Hb &Hemerythrin, transport mechanism, Co-operatively effect, Differences of Hemerythrin with hemoglobin and myoglobin.
Lecture 11	Electron transfer reactions: Biological electron flow, Oxidation & Reduction of Carbon, Reduction of NAD by two electrons, NADH.
Lecture 12	Kinetics of e-transfer reactions, Simplified Marcus theory, Efficient 'e' transfer in cytochromes
	UNIT - 2 Biophysical Chemistry
Lecture 1	Nitrogen fixation: Biological & non-biological N_2 fixation, Nitrogenase complexes,
Lecture 2	Metalloenzymes: definition, structure & their Physiological role.
Lecture 3	The peptide bond and primary structure of proteins, Amino acids & peptide bonds.
Lecture 4-5	Conformational properties of polypeptides: secondary structure α-helix, β-sheet structures etc., Ramachandran plot.
Lecture 6	Tertiary and quaternary structure: concept of structure of proteins and its stabilization.
Lecture 7	Membrane proteins structure & functions.

Lecture 8-9	Kinetics of protein folding unfolding, Temperature & solvent Induced Membrane Protein Denaturation.
Lecture 10	Thermodynamic considerations of protein folding & unfolding.
	UNIT - 3 Bioorganic Chemistry
Lecture 1-2	Carbohydrates & its classification, functions of carbohydrate in cells, Biologically active carbohydrates.
Lecture 3	Fatty acids, structure & nomenclature, geometric isomerization.
Lecture 4	Physical properties of saturated and unsaturated fatty acids, metabolism of fatty acids
Lecture 5	Nucleic acids and its type, chemistry of nucleic acids, Structure of DNA & RNA.
Lecture 6	Terpenes & their classification, biogenesis of terpenes.
Lecture 7	Steroids & their classification, biogenesis of steroids.
Lecture 8	Alkaloids & their classification, biogenesis of Alkaloids.

Name of Program		**M.Sc. Chemistry**
Name of Course		**Instrumental Methods of Analysis**
Course Code		**CY MS 533**
Core / Elective / Other		**Elective**
Credit		**3**
Prerequisite:		
1.	Student should have basic knowledge of spectrometry.	
2.	Student should know principle of extraction techniques.	
Course Outcomes: Student are expected to be able to		
1.	Know intricate instrument details of atomic absorption and fluorescence spectrometry.	
2.	Comparison study of absorption and emission spectrometry.	
3.	Understand the supercritical fluid extraction process.	
4.	Compare manual and automated extraction process and can apply various supercritical fluids.	
Description of Contents in brief:		
This course will cover working principle and instrument details of atomic and emission spectrometry along with chromatographic separations of supercritical fluids. Also, some of instrument demonstrations will be shown to students.		
Detailed Syllabus:		
1.	**Atomic Absorption and Atomic Fluorescence Spectrometry:** Sample Atomization Techniques, Atomic Absorption Instrumentation, Interferences in Atomic Absorption Spectroscopy, Atomic Absorption Analytical Techniques, Atomic Fluorescence Spectroscopy	
2.	**Atomic Emission Spectrometry**: Emission Spectroscopy Based on Plasma Sources, Emission Spectroscopy Based on Arc and Spark Sources, Miscellaneous Sources for Optical Emission Spectroscopy.	
3.	**Molecular Luminescence Spectrometry:** Theory of Fluorescence and Phosphorescence, Instruments for Measuring Fluorescence and Phosphorescence, Applications of Photoluminescence Methods, Chemiluminescence.	
4.	**Supercritical Fluid Chromatography and Extraction:** Properties of Supercritical Fluid, Supercritical Fluid Chromatography, Supercritical Fluid Extraction.	
5.	**Automated Methods of Analysis:** An Overview of Automatic Instruments and Instrumentation, Flow Injection Analysis, Discrete Automatic Systems, Analysis based upon Multilayer Films.	
List of Text Books:		
1.	Vogel's Textbook's of Quantitative analysis, Pearson Educaion, 6th Edition	
2.	Skoog A., Holler F. J., Crouch S. R., Principles of Instrumental Analysis, 9th Edition, Brooks/Cole Cengage Learning, Belmont, CA.	
3.	Christian, G.D., "Analytical Chemistry" 6th Ed. Wiley, 2008	
List of Reference Books:		
1.	Instrumental Methods of Chemical Analysis 5th edition by Chatwal and Anand	
Lecture Plan (about 42 lecture)		
Lecture No.	**Topic**	
	UNIT I: Atomic Absorption and Atomic Fluorescence Spectrometry	
Lecture 1	Sample Atomization Techniques - Introduction	

Lecture 2 Lecture 3 Lecture 4 Lecture 5-6 Lecture 7-9	Atomic Absorption Instrumentation Interferences in Atomic Absorption Spectroscopy Atomic Absorption Analytical Techniques Atomic Fluorescence Spectroscopy Problems and Solutions
	UNIT II: Atomic Emission Spectrometry
Lecture 1-2 Lecture 3-4 Lecture 5-6 Lecture 7-8	Emission Spectroscopy Based on Plasma Sources Emission Spectroscopy Based on Arc and Spark Sources Miscellaneous Sources for Optical Emission Spectroscopy Problems and Solutions
	UNIT III: Molecular Luminescence Spectrometry
Lecture 1-2 Lecture 3-4 Lecture 5-6 Lecture 7-8	Theory of Fluorescence and Phosphorescence Instruments for Measuring Fluorescence and Phosphorescence Applications of Photoluminescence Methods Chemiluminescence; Problems and Solutions
	UNIT IV: Supercritical Fluid Chromatography and Extraction
Lecture 1 Lecture 2-3 Lecture 4-5 Lecture 6-7 Lecture 8	Supercritical Fluid – Introduction Properties of Supercritical Fluid Supercritical Fluid Chromatography Supercritical Fluid Extraction Problems and Solutions
	UNIT V: Automated Methods of Analysis
Lecture 1-2 Lecture 3 Lecture 4-5 Lecture 6-7 Lecture 8-9	An Overview of Automatic Instruments and Instrumentation Flow Injection Analysis Discrete Automatic Systems Analysis based upon Multilayer Films Problems and Solutions

Name of Program	**M.Sc. Chemistry**
Name of Course	**Chemical and Statistical Thermodynamics**
Course Code	**CY MS 551**
Core / Elective / Other	**Elective**
Credit	**3**

Prerequisite:

1. Student should have knowledge and understanding of fundamentals of Physical chemistry, classical thermodynamics and kinetics.
2. Knowledge of basic statistical methods will be useful.
3. This is an optional course available for master's student to advance their knowledge in macroscopic chemical systems.

Course Outcomes: The students are expected to be able to:

1. Understand principles and applications classical thermodynamics.
2. Apply thermodynamic laws/calculations to predict feasibility of a reaction using given experimental data.
3. Learn the statistical models of thermodynamic properties of macroscopic systems.
4. Analyse the most probable distributions of a system among the energy levels using principles of statistical thermodynamics.
5. Apply statistical thermodynamics to various chemical systems.

Description of Contents in brief:

A part of the course covers classical thermodynamics laws and their applications for different type of systems. In the other part, various aspects of and statistical thermodynamics used to explain and interpret many of the physical and chemical observations. This course includes the macro- and microscopic states of the particle, introduce about molecular partition functions, and explains heat capacity behaviours and nuclear spin statistics.

Detailed Syllabus:

1. **Chemical Thermodynamics:** Thermodynamic laws, state and path functions and their applications; entropy and its change for an ideal gas, reversible/irreversible processes; entropy of phase transitions; Free energy and work function: Helmholtz and Gibbs free energy functions; Criteria of spontaneity; Gibbs-Helmholtz equation (problems); Clausius-Clapeyron equation; Maxwell relations – Van't Hoff isotherm and isochore.
2. **Phase Transition and Thermodynamics of Solutions:** Elementary description of phase transitions; phase equilibrium and phase rule; Partial molar properties i.e., free energy, volume and heat content and their significance. Concept of fugacity and determination of fugacity. Thermodynamics of ideal and non-ideal gases, and solutions. Functions for non-ideal solutions. Activity and activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.
3. **Macroscopic and microscopic states**: concepts of ensemble, Thermodynamic probability and entropy, distribution-Maxwell's and Boltzmann's distribution. Thermodynamic probability and kinetic theory of gases.
4. **Concept of Partition functions:** and their relation to thermodynamic quantities, calculations for model systems. Canonical, grand canonical and micro canonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined

	multipliers). Partition functions- translational, rotational, vibrational electronic partition functions, calculation of thermodynamic properties in terms of partition functions, applications of partition functions.
5	**Heat capacity:** Chemical equilibrium constant in terms of partition function. Femi-dirac statistics, distribution law and applications, Bose-Einstein statistics- distribution law and applications. Ideal Fermi gas, Ideal Bose gas.
List of Text Books:	
1.	Hill, Terrell L. An Introduction to Statistical Thermodynamics. United States, Dover Publications, 2012.
2.	Sears and Salinger Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa Publishing House, New Delhi.
3.	P. W. Atkins, Physical Chemistry, 6th Edn., Oxford University Press
4.	D. McQuarie, and J. D. Simmen, Physical Chemistry.
5.	Puri, Sharma, Pathaniya, Principles of Physical Chemistry, Vishal Publications
List of Reference Books:	
1.	M.C.Gupta, Statistical Thermodynamics, 2007, 2nd Edition, New Age International Pvt. Ltd, New Delhi
2.	Pitaevskii, L. P., and Lifshitz, E.M.. Statistical Physics: Theory of the Condensed State. United Kingdom, Elsevier Science, 2013.
3.	Herbert b. Callen, Thermodynamics & an introduction To Thermostatistics. India, Wiley indiapvt. Limited, 2006.
4.	Silbey, R. J.; Alberty, R. A. &Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
5.	Kalidas, C. &Sangaranarayanan, M.V. Non-Equilibrium Thermodynamics: Principles & Applications, Macmillan India Ltd. (2002).

Lecture Plan (about 42 Lectures):

Lecture No.	Topic
	UNIT –I: Macroscopic and microscopic states
Lecture 1	State and path functions, Concept Q, W, U, and First law
Lecture 2	Concept of enthalpy, H & relation between heat capacities
Lecture 3	Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases under isothermal and adiabatic conditions
Lecture 4	Thermochemistry: Heats of reactions and its applications; effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions
Lecture 5	Second Law: Concept of entropy, thermodynamic scale of temperature, statement of the second law of thermodynamics
Lecture 6	Calculation of entropy change for reversible and irreversible processes
Lecture 7	Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules
Lecture 8	Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity
Lecture 9-11	Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state
Lecture 12-13	Systems of Variable Composition: Partial molar quantities, dependence of thermodynamic parameters on composition
Lecture 14	Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases
Lecture 15	Free energy of mixing and spontaneity
	UNIT II: Phase Transition and Thermodynamics of Solutions

Lecture 1	Criteria of thermodynamic equilibrium, degree of advancement of reaction
Lecture 2	Phase transitions; phase equilibrium and phase rule; Partial molar properties and their significance
Lecture 3	Concept of fugacity and determination of fugacity. Activity and activity coefficient
Lecture 4-5	Thermodynamics of ideal and non-ideal gases, and solutions. Functions for non-ideal solutions
Lecture 6	Activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength
	UNIT III: Macroscopic and Microscopic States
Lecture 1-2	Macroscopic and microscopic states; concepts of ensemble Boltzmann distribution
Lecture 3	Thermodynamic probability and entropy, distribution-Maxwell's and
Lecture 4	Boltzmann's distribution
Lecture 5-6	Thermodynamic probability and kinetic theory of gases
	Examples based on Thermodynamic probability and kinetic theory of gases
	UNIT IV: Concepts of Partition Functions
Lecture 1	Introduction to molecular Partition functions
Lecture 2-4	Partition function: relation to thermodynamic quantities, model systems.
Lecture 5	Canonical, grand canonical and micro canonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers)
Lecture 6	Translational and electronic partition functions and Applications
Lecture 7	Rotational Partition functions and applications
Lecture 8-9	Vibrational and Nuclear partition functions and Applications
	Applications of thermodynamic properties in terms of partition functions
	UNIT V: Heat capacity
Lecture 1-3	Heat capacity behaviour of solids- chemical equilibrium constant in terms of partition function
Lecture 4	Femi-Dirac statistics, distribution law and applications
Lecture 5	Bose-Einstein statistics- distribution law and applications
Lecture 6	Ideal Fermi gas, Ideal Bose gas

Name of Program	**M.Sc. Chemistry**
Name of Course	**Optical Imaging and Ultrafast Spectroscopy**
Course Code	**CY MS 552**
Core / Elective / Other	**Elective**
Credit	**3**

Prerequisite:	
1.	Student should have knowledge and understanding of basic spectroscopy and photochemistry.
2.	An understanding of optics and elements of spectroscopy will be useful.
3.	This is an optional course available for master's student to advance their knowledge in optical imaging and ultrafast spectroscopy.
Course Outcomes: The students are expected to be able to:	
1.	Describe fundamental concept and applications of lasers, X-Rays in spectroscopy.
2.	Explain basic elements of optical systems, imaging, and microscopy.
3.	Compare different imaging methods and its applications in studying photochemical and photophysical processes.
4.	Define Auger electron and X-ray fluorescence spectroscopy.
Description of Contents in brief:	
This course will cover various aspects of laser based optical imaging and ultrafast spectroscopy. Principle, methods and applications of optical microscopy, steady state and time resolved spectral methods will be discussed. Students will develop understanding of these methods and tools to apply in chemical/materials research.	
Detailed Syllabus:	
1.	**Laser Basics**: Principle of lasers and laser technology, stimulated emission, population inversion, light amplification, comparison between conventional light sources and lasers, CW and Pulsed laser: cavity dumping, Q-switching and the generation of nanosecond pulses, Mode locking and the generation of picosecond and femtosecond pulses. LASERS as spectroscopy light source.
2.	**Optical systems and Microscopy**: Light Sources, Monochromators, Filters, Fundamentals of optical microscopy, point spread function, wide-field optical microscopy, bright and dark field microscopy, polarization, phase contrast and differential interference contrast microscopy (DIC) microscopy. Confocal fluorescence and confocal reflectance microscopy. Instrumentation for detection of optical signals and time-resolved measurements.
3.	**Application of LASERs in Imaging and Spectroscopy**: Laser induced fluorescence and Raman Spectroscopy, Doppler limited absorption and fluorescence with lasers. Excitation, Ionization and Stark's spectroscopy. Circular dichroism spectroscopy, fluorescence spectroscopy and microscopy. Scattering, Steady state and time-resolved Resonance Raman spectroscopy, Surface Enhanced Raman (SERS), Coherent anti-stokes Raman spectroscopy (CARS). Stimulated Raman spectroscopy.
4.	**Ultrafast Spectroscopy:** Absorption measurements on excited states, flash photolysis/transient absorption, and photogenerated excited state absorption energies and associated lifetimes of molecules, two-photon absorption measurements. Excited state

	lifetime and its detection Introduction to measurements, detection and kinetics of reactive intermediates. Time correlated single photon count (TCSPC) technique, ultrafast dynamics in nanomaterial and novel fluorophores.
5.	**X-ray fluorescence spectroscopy:** Auger electron spectroscopy, Experimental method Processes in Auger electron ejection, Examples of Auger electron spectra, X-ray fluorescence spectroscopy, Experimental method, Processes in X-ray fluorescence, Examples of X-ray fluorescence spectra, Extended X-ray absorption fine structure
List of Text Books:	
1.	V.P. Gupta. Molecular and Laser Spectroscopy: Advances and Applications. Netherlands, Elsevier Science, 2017.
2.	Lakowicz, J. R. Principles of fluorescence Spectroscopy 3rd ed, 2006, Plenum, New York.
3.	J. M. Hollas, Modern spectroscopy, Wiley, New York, 2004
4.	Fluorescence Spectroscopy and Microscopy: Methods and Protocols. United States, Humana Press, 2014.
5.	Optical Spectroscopy (Demtroder), Quantum Electronics – Yariv, Building Scientific Apparatus – WJ Moore
List of Reference Books:	
1.	Douhal, A. ed. Femtochemistry and Femtobiology : ultrafast dynamics in molecular science . 2002 World Scientific.
2.	H. H. Telle, A. G. Urena, R. J. Donovan Laser Chemistry: Spectroscopy, Dynamics and Applications, Wiley, 2007.
3.	ArnulfMaterny, Manik Pradhan, Dheeraj Kumar Singh, Modern Techniques of Spectroscopy: Basics, Instrumentation, and Applications. Germany, Springer Singapore. 2021
4.	Hofmann, Siegfried. Auger- and X-Ray Photoelectron Spectroscopy in Materials Science: A User-Oriented Guide. Germany, Springer, 2012.
5.	*Yutaka Yoshida, Guido Langouche, Modern Mössbauer Spectroscopy: New Challenges Based on Cutting-Edge Techniques. Germany, Springer Singapore, 2021*

Lecture Plan (40 Lectures):

Lecture No.	Topic
	UNIT – I: LASER Basics
Lecture 1	Brief review on molecular spectroscopy
Lecture 2	Principle of lasers and laser technology
Lecture 3	Introduction to LASERS as light source: CW and Pulsed laser
Lecture 4	CW & Pulsed LASERS and their applications
Lecture 5-6	Mode locking and the generation of picosecond and femtosecond pulses
Lecture 7-9	LASERS in Spectroscopy and Microscopy
	UNIT – II: Optical systems and Microscopy
Lecture 1	Light Sources, Monochromators, Filters.
Lecture 2	Fundamentals of optical microscopy, point spread function.
Lecture 3	Wide-field optical microscopy, bright and dark field microscopy, polarization.
Lecture 4	Continued…
Lecture 5	Phase contrast and differential interference contrast microscopy (DIC)
Lecture 6-7	microscopy Confocal fluorescence and confocal reflectance microscopy.
	UNIT – III: Application of LASERs in Spectroscopy
Lecture 1	Laser induced fluorescence and Raman Spectroscopy.
Lecture 2	Doppler limited absorption and fluorescence with lasers.
Lecture 3	Excitation, Ionization and Stark's spectroscopy.

Lecture 4	Continued...
Lecture 5	Circular dichroism spectroscopy and applications.
Lecture 6	Fluorescence spectroscopy and microscopy.
Lecture 7	Confocal fluorescence and confocal reflectance microscopy. Scattering,
Lecture 8	Steady state and time-resolved Resonance Raman spectroscopy.
Lecture 9	Surface Enhanced Raman (SERS), Coherent anti-stokes Raman spectroscopy (CARS). Stimulated Raman spectroscopy.
	UNIT - IV Ultrafast spectroscopy
Lecture 1	Ab Absorption measurements on excited states, flash photolysis/transient absorption.
Lecture 2	Photogenerated excited state absorption energies and associated lifetimes of molecules.
Lecture 3	Two-photon absorption measurements.
Lecture 4	Excited state lifetime and its detection Introduction to measurements, detection and kinetics of reactive intermediates.
Lecture 5	Continued...
Lecture 6	Time correlated single photon count (TCSPC) technique.
Lecture 7	Continued...
Lecture 8-9	Ultrafast dynamics in nanomaterial and novel fluorophores.
	UNIT - IV X-ray fluorescence spectroscopy:
Lecture 1	Introduction X-ray generation and continuous radiation. X-Ray Fluorescence spectroscopy
Lecture 2	Experimental method, Processes in X-ray fluorescence, Examples of X-ray fluorescence spectra
Lecture 3	Extended X-ray absorption fine structure. Various methods based on X-Ray and applications,
Lecture 4	Methods based on X-Ray and applications
Lecture 5	Auger electron spectroscopy, Experimental method and Processes
Lecture 6	in Auger electron ejection
Lecture 7	Examples and Applications of Auger electron spectroscopy
Lecture 8	Continue…

Name of the Program	**M.Sc. Chemistry**
Name of Course	**Research Methodology in Chemistry**
Course Code	**CY MS 553**
Core / Elective / Other	**Elective**
Credit	**3**

Prerequisite:	
1.	Student should have sound knowledge of basics of chemistry, like atomic structure, bonding, chemical reactions, periodic table, their properties etc.
2.	Student should have the capability to understand how chemistry can explain various concepts of technology.
3.	Basic mathematics for doing calculations and numerical problems is desired.
Course Outcomes:	
1.	To enable students to undertake independent research of a problem in chemistry, and to analyze and present their findings.
2.	To familiarize students with the basic techniques of collection, analysis, interpretation and presentation of data.
3.	To formulate a comprehensive, logical, and comprehensible project proposal.
4.	To be familiar with basic techniques relevant to the analysis of quantitative and qualitative data.
Description of Contents in brief:	
1.	Information and resources: Sources and their authenticity, methods for collecting information- search Engines, Google scholar, Scifinder, Web of Science, Scopus; Features of Chemdraw and its uses; searching of chemical resources, reactions, reagents and their chemical and physical properties.
2.	Data collection: Spectral data bases, NMR data bases, CCDC, PDB, JCPDS, NIST. Recording of experiments: Log book and lab notebook, accuracy, precision, fitting of data, error bar, noise and data, IUPAC guidelines of presentation of data for experimental and theoretical studies. Figures, legends, tables, foot notes, abbreviations, references, different software used for plotting. Typesetting, templates, formulas and equations, reference formats, supplementary data
3.	Writing style: Abstract, report, dissertation, thesis, manuscript, monographs, books, research proposals. Types of publications: letters, communications, perspectives, research articles, reviews, accounts. Outline, drafting, refinement, common errors, editing services, proof reading
4.	Ethics in research and publishing: Authorship, plagiarism, checking of plagiarism, duplicate and redundant publications, copyright, open access licenses, embargo period, and repositories. Conflicts of interest, Bio-ethics. Social networks for promotion. Review, Originality, physical insights, reproducibility, Renowned publishers in the field of chemistry, citations, impact factor, Ranking: journals, institutes (e.g. NIRF), individuals, h-index, i-index, i-10 index, Author identification: ORCID and RESEARCHER IDs, ISSN and ISBN, Intellectual property rights
5.	Presentation: Different modes: board, poster, power-point, audio-visual.
List of Text Books:	
1.	Kothari, C. R., “Research Methodology Methods and Techniques”, 2nd Ed, Vishwa Prakashan. 2006

2.	Kumar, Ranjit, "Research Methodology: A step by step guide for beginners", Sage Publications, 3rd Edn. 2011
3.	Ebel, H. F., Bliefert, C., and Russey, W. E., "The Art of Scientific Writing", WileyVCH, 2nd Edn. 2004
List of Reference Books:	
1.	Hoffman, A., "Scientific Writing and Communication", Oxford University Press, 2 nd Edn. 2014
2.	Strunk, W. Jr. and White, E.B., "The Elements of Style", Allyn and Bacon, 4th Edn. 2003
3.	Tufte, E. R., "The Visual Display of Quantitative information", Graphics Press, 2nd Edn 2001
4.	Katz, M. J., "From Research to Manuscripts: A Guide to Scientific Research", Springer, 2nd Edn. 2009

Lecture Plan (About 30 Lectures):

Lecture No.	Topic
	UNIT – I: Information and resources
Lecture 1	Sources and their authenticity
Lecture 2	Methods for collecting information- search Engines, Google scholar, Scifinder, Web of Science, Scopus
Lecture 3	Features of Chemdraw and its uses
Lecture 4	Features of Chemdraw and its uses continued
Lecture 5	Searching of chemical resources
Lecture 6	Searching of reactions, reagents and their chemical and physical properties.
	UNIT – II: Data collection
Lecture 1	Spectral data bases, NMR data bases, CCDC, PDB, JCPDS, NIST.
Lecture 2	Recording of experiments: Log book and lab notebook,
Lecture 3	Accuracy, precision, fitting of data, error bar, noise and data
Lecture 4	IUPAC guidelines of presentation of data for experimental and theoretical studies.
Lecture 5	Figures, legends, tables, foot notes, abbreviations, references, different software used for plotting.
Lecture 6	Typesetting, templates, formulas and equations, reference formats, supplementary data
	UNIT - III Writing style
Lecture 1	Abstract, report, dissertation
Lecture 2	Thesis, manuscript, monographs
Lecture 3	Books, research proposals.
Lecture 4	Types of publications: letters, communications, perspectives Research
Lecture 5	articles, reviews, accounts.
Lecture 6	Outline, drafting, refinement
Lecture 7	Common errors, editing services
Lecture 8	Proof reading
	UNIT – IV: Ethics in research and publishing
Lecture 1	Authorship, plagiarism, checking of plagiarism, duplicate and redundant publications, copyright
Lecture 2	Open access licenses, embargo period, and repositories.
Lecture 3	Conflicts of interest, Bio-ethics.
Lecture 4	Social networks for promotion.
Lecture 5	Review, Originality, physical insights, reproducibility, Renowned publishers in the field of chemistry, citations, impact factor

Lecture 6	Ranking: journals, institutes (e.g. NIRF), individuals, h-index, i-index, i-10 index
Lecture 7 Lecture 8	Author identification: ORCID and RESEARCHER IDs, ISSN and ISBN, Intellectual property rights
	UNIT – V: Presentation
Lecture 1	Different modes: board, poster
Lecture 2	Power-point, audio-visual.

Name of Program	**M.Sc. Chemistry**
Name of Course	**Photophysical Chemistry**
Course Code	**CY MS 654**
Core / Elective / Other	**Elective**
Credit	**3**

Prerequisite:	
1.	Student should have knowledge and understanding of basic chemistry and spectroscopy.
2.	Basic idea of Quantum Mechanics and Group Theory will be helpful.
3.	This is an optional course available for master's student to advance their understanding in Photophysical chemistry.
Course Outcomes: The students are expected to be able to:	
1.	Assess Photochemistry and Photophysics Principles.
2.	Describe photo induced electron transfer mechanism and energetics.
3.	Illustrate fluorescence resonance energy transfer (FRET), Chemiluminescence methods and applications.
4.	Identify applications involving photochemistry and photophysical.
Description of Contents in brief:	
This course will cover conceptual aspects of photochemistry, photophysical processes, photo-excited states, electron transfer mechanism, factors affecting it and energy transfer process etc. Various applications of photophysical processes will cover in this source. Students will learn photophysical concepts to explore in chemical/materials research.	
Detailed Syllabus:	
1.	**Principles and concepts of photochemistry**: interaction of light with matter, Grotthuss-Draper and Stark-Einstein Law, Einstein's coefficients with transition moments (no derivation) and transition probabilities, oscillator strength, Beer-Lambert Law, relationship between Einstein's coefficient and total absorbance.
2.	**Photophysical Processes**: Singlet triplet states, intensity and strength of electronic transition, electronic energy levels and selection rules for electronic transition, Franck-Condon principle. Jablonski diagram and photophysical processes Radiative (fluorescence, phosphorescence etc.) and non-radiative transitions, absorption and emission spectra, quantum yield and determination of quantum efficiency of Some Reactions. Quantum yield of fluorescence and phosphorescence, expressions for examples of ground state charge transfer, excimer and exciplex, luminescence quenching: static and dynamic, Stern-Volmer analysis, deviation from Stern-Volmer kinetics. Factors affecting excited state energy, solvent effect on spectra, non-specific and specific interaction (H-bonding and charge transfer), and Characteristics of CT interaction.
3.	**Electron transfer mechanism and Energetics**: Energy transfer and electron transfer, Electron exchange interactions for energy and electron transfer, Visualization of energy transfer by Dipole-Dipole interaction, Quantitative aspects of Forster theory of Dipole-Dipole Energy Transfer, Triplet –triplet annihilation: special case of energy transfer via electron exchange interactions. Markus Theory and examples of Photo induced electron transfer. Mechanism of long distance electron transfer, through space and through bond interactions.

4.	**Photo induced energy transfer rates**, free energy dependence of electron transfer on rate; fluorescence resonance energy transfer (FRET), FRET, rate and efficiency calculation of FRET. Chemiluminescence, detection systems and applications.
5.	**Applications of photophysical chemistry**: Photochromism, Luminescent Sensors, Solar Cells, Dye-Sensitized Solar Cells (DSSCs), Electroluminescent Materials, Light-Emitting Diodes (LEDs), Organic Light Emitting Diodes (OLEDs), Photo-polymerization, Photo degradation, Photolithography etc.
List of Text Books:	
1.	GiacomoBergamini, Serena Silvi , Applied Photochemistry: When Light Meets Molecules. Germany, Springer International Publishing. 2016
2.	Lakowicz, J. R. Principles of fluorescence Spectroscopy 3rd ed, 2006, Plenum, New York.
3.	J. M. Hollas, Modern spectroscopy, Wiley, New York, 2004
4.	Johnson, Nathan A., and Smith, Abigail B. Photochemistry: New Research. United States, Nova Science Publishers, Incorporated, 2013.
5.	Ninomiya, I., and Naito, T., Photochemical Synthesis, Academic Press, New York (1989).
List of Reference Books:	
1.	Ramamurthy, V., and Scaiano, J. C., Modern Molecular Photochemistry of Organic Molecules, University Science, Books, CA (2010)
2.	Balzani, Vincenzo, et al. Photochemistry and Photophysics: Concepts, Research, Applications. Germany, Wiley, 2014.
3.	ArnulfMaterny, Manik Pradhan, Dheeraj Kumar Singh, Modern Techniques of Spectroscopy: Basics, Instrumentation, and Applications. Germany, Springer Singapore. 2021
4.	Wardle, Brian. Principles and Applications of Photochemistry. Germany, Wiley, 2009.
5.	Kavarnos, G. J., Fundamentals of Photoinduced Electron Transfer, VCH publishers Inc., New York (1993).

Lecture Plan (42 Lectures):

Lecture No.	Topic
	UNIT - 1 Principles and concepts of photochemistry
Lecture 1	Historical background on photochemistry.
Lecture 2	Principles and concepts of photochemistry: interaction of light with matter,
Lecture 3	Grotthuss-Draper and Stark-Einstein Law.
Lecture 4	Einstein's coefficients with transition moments (no derivation) and transition probabilities, oscillator strength
Lecture 5	Effect of Vibration on Transition between Electronic States: The Frank codon Principle
Lecture 6	Classical and semi-classical Harmonic Oscillator model of the Frank-Codon principle for radiative Transitions.
Lecture 7	Beer-Lambert Law and its applications, relationship between Einstein's coefficient and total absorbance.
Lecture 8	Continued…
Lecture 9	Absorption, Emission and Excitation Spectra
	Continued…
	UNIT - 2 Photophysical Processes

Lecture 1-3	Singlet triplet states, intensity and strength of electronic transition, electronic energy levels and selection rules for electronic transition, Franck-Condon principle.
Lecture 4 Lecture 5	Jablonski diagram and photophysical processes Radiative (fluorescence, phosphorescence etc.) and non-radiative transitions, absorption and emission spectra.
Lecture 6	Quantum yield and determination of quantum efficiency of fluorescence and phosphorescence.
Lecture 7	Luminescence quenching: static and dynamic, Stern-Volmer analysis, deviation from Stern-Volmer kinetics. Numerical on quantum yield.
Lecture 8 Lecture 9	Factors affecting excited state energy, solvent effect on spectra, non-specific and specific interaction (H-bonding and charge transfer), and Characteristics of CT interaction.
	UNIT - 3 Electron transfer mechanism and Energetics
Lecture 1-2	Energy transfer and electron transfer, Electron exchange interactions for energy and electron transfer.
Lecture 3	Visualization of energy transfer by Dipole-Dipole interaction
Lecture 4	Quantitative aspects of Forster theory of Dipole-Dipole Energy Transfer
Lecture 5	Triplet –triplet annihilation: special case of energy transfer via electron exchange interactions Continued…
Lecture 6 Lecture 7	Markus Theory and examples of Photo induced electron transfer Markus Theory and examples of Photo induced electron transfer
Lecture 8 Lecture 9 Lecture10	Mechanism of long distance electron transfer, through space and through bond interactions. Continued…
	UNIT - 4 Energy transfer and Chemiluminescence
Lecture 1-2	Examples of fluorescence based sensors: Molecular and Supramolecular systems.
Lecture 3	Fluorescence resonance energy transfer (FRET), FRET, rate and efficiency calculation of FRET
Lecture 4	FRET based sensors and applications
Lecture 5	Continued…
Lecture 6	Chemiluminescence, detection systems and applications.
Lecture 7	Continued…
	UNIT - 5 Applications of photophysical chemistry
Lecture 1-2	Conversion of solar energy to chemical and other forms of energies, Photochromism , Luminescent Sensors etc.
Lecture 3	Solar photovoltaic cell, basic principle and design of the cell.
Lecture 4	Dye-Sensitized Solar Cells (DSSCs),
Lecture 5 Lecture 6	Electroluminescent Materials, Light-Emitting Diodes (LEDs), Organic Light Emitting Diodes (OLEDs),
Lecture 7	Photo-polymerization, Photo degradation, Photolithography etc.

Name of Program	**M.Sc. Chemistry**
Name of Course	**Synthon Approaches in Organic Synthesis**
Course Code	**CY MS 655**
Core/ Elective/ Other	**Elective**
Credit	**3**

Prerequisite:

Basic knowledge of organic chemistry

Course Outcome: Students are expected

1.	To be familiar with basic concepts of synthon approach explaining one- & two-group C-X and C-C disconnections, chemoselectivity, reversal of polarity, amine synthesis, stereoselectivity, stereospecificity, regioselectivity and regiospecificity.
2.	To apply the concept of disconnection approach for the synthesis of drug molecules.
3.	To apprise of protection of important functional groups (alcoholic, amino, carbonyl and carboxylic groups).

Description of Content in Brief:

The course describes the principles of synthetic chemistry like the synthon approach, protection, and their application in drugs.

Detailed Syllabus:

1.	**Introduction to Synthon Approach:** Definition of terms- Disconnection, synthons, functional group interconversions (FGI), synthetic equivalents. General principles of the disconnection approach, the importance of order of events in organic synthesis.
2.	**Basics of Disconnection Approach:** One group C-X and two group C-X, One group C-C disconnections-alcohols and carbonyl compounds, chemoselectivity, reversal of polarity, amine synthesis.
3.	**Synthon approach-II:** Two group C-C disconnections-1, 3 & 1,5-difunctionalized compounds, Stereochemistry in organic synthesis-stereoselectivity, stereospecificity, regioselectivity and regiospecificity.
4.	**Synthon approach in the synthesis of the following drugs:** Salbutamol, Propanolol, moxnidazole, nafimidone, drildone, belfosih. Ocfentanil, afornine Principle of protection of alcoholic, amino, carbonyl and carboxylic groups.
5.	**Medicinal Uses of Important drugs:** An introduction to AIDS, how HIV infects the system, mode of action of nucleoside reverse transcriptase inhibitors- AZT, ddI, ddC, d4T & 3TC and HIV-protease inhibitors-Ritonavir. Synthesis of AZT. An overview of HIV entry inhibitors, Integrase inhibitors, Chemokine receptor binders, and Inhibitors of gp41 fusion activity.

List of Books:

1.	Designing Organic Synthesis, S.Warren, Wiley.
2.	Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3.	Modern Synthetic Reactions, H. O. House, W.A. Benzamin.
4.	Advanced Organic Chemistry Reactions, Mechanisms a Structures, J. March, Wiley.

Lecture Plan : About 42 Lectures

Lecture No.	Topic
	UNIT I: Introduction to Synthon approach
Lecture 1	Definition of terms- disconnection, synthons
Lecture 2-3	Functional group interconversions (FGI), synthetic equivalents.

Lecture 4-5	General principles of the disconnection approach
Lecture 6-8	Importance of order of events in organic synthesis
Lecture 9	Applications
	UNIT II: Basics of Disconnection Approach
Lecture 1-2	One group C-X and two group C-X, One group C-C disconnections-alcohols
Lecture 3-4	One group C-X and two group C-X, One group C-C disconnections-carbonyl compounds
Lecture 5	Chemoselectivity
Lecture 6	Reversal of polarity
Lecture 7-8	Amine synthesis
Lecture 9	Applications
	UNIT III: Synthon approach-II
Lecture 1-3	Two group C-C disconnections-1, 3 & 1,5-difunctionalized compounds
Lecture 4	Stereochemistry in organic synthesis-stereoselectivity
Lecture 5	Stereochemistry in organic synthesis- stereospecificity
Lecture 6	Stereochemistry in organic synthesis- regioselectivity
Lecture 7	Stereochemistry in organic synthesis- regiospecificity
Lecture 8	Applications
	UNIT IV: Synthon approach in the synthesis of the following drugs
Lecture 1	Synthesis: Salbutamol, Propanolol,
Lecture 2	Synthesis: Moxnidazole, Nafimidone
Lecture 3	Synthesis: Drildone, Belfosih
Lecture 4	Synthesis: Ocfentanil, Afornine
Lecture 5-7	Principle of protection of alcoholic, amino, carbonyl and carboxylic groups.
	UNIT V: Medicinal Uses of Important Drugs
Lecture 1	An introduction to AIDS, how HIV infects the system
Lecture 2-4	Mode of action of nucleoside reverse transcriptase inhibitors- AZT, ddI, ddC, d4T & 3TC and HIV-protease inhibitors-Ritonavir
Lecture 5	Synthesis of AZT
Lecture 6	An overview of HIV entry inhibitors
Lecture 7	Integrase inhibitors, Chemokine receptor binders
Lecture 8	Inhibitors of gp41 fusion activity
Lecture 9	Applications

Name of Program	**M.Sc. Chemistry**
Name of Course	**Radiations and Nuclear Chemistry**
Course Code	**CY MS 656**
Core / Elective / Other	**Core**
Credit	**3**
Prerequisite: NIL	
Course Outcomes: Students will able to	
1	Apply principle of nuclear structure, model & mechanism of nuclear radiation
2	Understand application of nuclear radiation with matter
3	Identify measurement techniques for nuclear radiation
4	Connect with Nuclear reactors in India
5	Contribute to the national laboratory R & D sector
Description of Contents in Brief	
This course discusses nature & stability of nuclear reaction, importance of Radio and Nuclear chemistry to mankind particularly in medical field. Also, the course gives status of Nuclear reactors in India & how to do waste management of Radioactive materials	
Detailed Syllabus	
1	**UNIT-I: Introduction to Nuclear Chemistry** Properties, shape & energy of nucleons and nuclei; Nuclear stability and natural radioactivity, size and shape of a nucleus, nuclear spin, magnetic properties of a nucleus, nuclear magnetic resonance, nuclear resonance or recoil-less absorption, electric quadrupole moment, nuclear parity and nuclear statistics. Nuclear models: Shell model, liquid drop model, Fermi gas model, collective model and optical model. Nuclear reaction: Bethe's notation, types of nuclear reaction, reaction cross section, Q- value and threshold, compound nucleus theory, trans-uranium, photo and thermonuclear reaction, fusion reactor, nuclear fission, fission fragments and mass distribution, basic design of fission reactor.
2	**UNIT-II: Radioactivity** Radioactive decay, decay kinetics, parent-daughter decay growth relationship, concepts of transient and secular equilibrium, alpha, beta and gamma decay, artificial radioactivity. Radioactive dating process.
3	**UNIT-III: Interaction of nuclear radiation with matter** Stopping power and range for charged particles, interaction with X-rays and gamma rays – photoelectric effect, Compton scattering, pair production, nuclear detectors -Gas detector, solid state detector & its use in materials science.
4	**UNIT-IV: Analytical-based nuclear techniques**

	Neutron Activation analysis with case studies, Rutherford backscattering spectrometry, radioisotopes for nuclear medicine, elemental mapping of trace and major elements, depth-wise analysis by RBS, elastic recoil deflection analysis for hydrogen measurement, ion implantation, ion beam mixing.
5	**UNIT-V: Nuclear reactor system in India** Introduction to the reactor system, classification of the reactor, reactor materials & selection criteria for it. Three stages nuclear reactor program in India, Nuclear waste management.
List of Text Books	
1	Principle of Nuclear chemistry; Peter A C Mcpherson World Scientific publisher
2	Essentials of Nuclear chemistry H J Arnicker, New Age international publisher
3	Radio and Nuclear chemistry; Gregory Choppin Elsevier
List of Reference Books	
1.	NUCLEAR CHEMISTRY: Step by Step Approach: Both Theory and Calculation Aspects; OPARA ISAIAH
Lecture Plan: About 42 lectures	
Lecture No.	**Topic**
	UNIT I: **Introduction to Nuclear Chemistry**
Lecture 1	Properties, shape & energy of nucleons and nuclei
Lecture 2	Nuclear stability and natural radioactivity, size and shape of a nucleus
Lecture 3	Nuclear spin, magnetic properties of a nucleus, nuclear magnetic resonance
Lecture 4	Nuclear resonance or recoil-less absorption, electric quadrupole moment
Lecture 5	Nuclear parity and nuclear statistics
Lecture 6-7	Nuclear models: Shell model, liquid drop model, Fermi gas model, collective model and optical model
Lecture 8-9	Nuclear reaction: Bethe's notation, types of nuclear reaction, reaction cross section, Q- value and threshold, compound nucleus theory, trans-uranium, photo and thermonuclear reaction, fusion reactor, nuclear fission, fission fragments and mass distribution, basic design of fission reactor
	UNIT II: Radioactivity
Lecture 1	Radioactive decay, decay kinetics
Lecture 2	Parent daughter decay growth relationship
Lecture 3	Concepts of transient and secular equilibrium, alpha, beta and gamma decay
Lecture 4	Artificial radioactivity
Lecture 5-8	Radioactive dating process
	UNIT III: Interaction of nuclear radiation with matter

Lecture 1	Introduction of radiation with matter
Lecture 2	Stopping power and range for charged particles
Lecture 3	Interaction with X-rays and gamma rays – photoelectric effect
Lecture 4	Compton scattering
Lecture 5	Pair production
Lecture 6	Nuclear detectors -Gas detector, solid-state detector
Lecture 7-8	Nuclear detectors use in materials science
	UNIT IV: Analytical-based nuclear techniques
Lecture 1-2	Neutron Activation analysis with case studies Rutherford back scattering spectrometry
Lecture 3	Radioisotopes for nuclear medicine
Lecture 4	Elemental mapping of trace and major elements
Lecture 5-6	Depth wise analysis by RBS, elastic recoil deflection analysis for hydrogen measurement
Lecture 7-10	Ion implantation, ion beam mixing
	UNIT V: Nuclear reactor system in India
Lecture 1-2	Introduction to nuclear reactor system used in India, classification of reactor
Lecture 3	Reactor materials & selection criteria for it
Lecture 4-5	Three stages nuclear reactor program in India
Lecture 6-7	Nuclear waste management

Name of Program	**M.Sc. Chemistry**
Name of Course	**Inorganic Chemistry I** **(Coordination Chemistry and Reaction Mechanism)**
Course Code	**CY MS 512**
Core/ Elective/ Other	**Core**
Credit	**3**
Prerequisite: NIL	
Course Outcome: The students are expected to be able to:	
1	Compare bonding theories of coordination compounds.
2	Illustrate the electronic transition & spectral properties of coordination complex.
3	Understand stability/thermodynamic & rate/kinetic of coordination complex
4	Interpret structure, spectral & magnetic properties of Lanthanides & Actinides elements.
Description of Content in Brief	
This course will cover various properties of coordination, inner transition element compounds which help students to understand conceptualize and apply similar compounds.	
Detailed Syllabus	
1	**UNIT I: Coordination chemistry** Introduction, classification of ligands, Structure, and isomerism of coordination compounds, VBT, CFT, MOT/LFT theory and examples of the complex. Energy level diagrams in various crystal fields.
2	**UNIT II: Crystal Field Stabilization Energy** Applications of CFT, d-orbital splitting in (octahedral, tetrahedral, square pyramidal, trigonal bipyramidal) Jahn-Teller distortion, spectrochemical series, Nephelauxetic series.
3	**UNIT III: Thermodynamic and kinetic aspects of coordination compound** Ligand substitution and electron transfer reaction of octahedral & square planar complexes. Reaction mechanism of transition metal complexes: Mechanism of electron transfer reactions - Outer-sphere & inner – sphere reactions, Marcus-Hush theory.
4	**UNIT IV: Electronic spectra of transition metal complexes** Comparison of electronic transitions of molecules and complexes, spectroscopic term symbols, selection rules, d-d transition, charge-transfer transition (MLCT & LMCT), Orgel diagrams, Tanabe Sugano diagram, magnetic properties & measurements
5	**UNIT V: Inner transition elements** Periodic properties, electronic configurations, comparison studies of lanthanides & actinides, lanthanide and actinide contractions, spectral and magnetic properties, redox chemistry, and analytical applications.

List of Text Books	
1	Inorganic Chemistry by F Albert Cotton, Geoffrey Wilkinson John Wiley Publisher
2	Inorganic Chemistry: Principles of Structure and reactivity by James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi. Pearson Publisher (5th edition)
3	Inorganic Chemistry by D. F. Shiver, P W Atkins. Oxford Publisher
4	Inorganic Chemistry by Alan G. Sharpe. Adison Wesley Publisher (3rd edition)
5	Selected topics in Inorganic chemistry by Madan, Tuli, Wahid U. Mallik. S. Chand Publisher
List of Reference Books	
1	Mechanism of Inorganic Reactions: F. Basalo and R. G. Pearson, Wiley Eastern publication 1967
2	Inorganic chemistry: E Catherine, Housechroft & Alan G. Sharpe, Pearson (5th edition)
Lecture Plan (about 42 lecture)	
Lecture No.	**Topic**
	UNIT I: Coordination chemistry
Lecture 1	Quick overview of bonding in ionic & covalent bonds, geometry of molecules by VSEPR theory.
Lecture 2	Introduction to coordination compound, history and classification of coordination complex
Lecture 3-4	Isomerism in coordination complexes, geometrical & optical isomerism Coordination number from 1 to 8 & higher number complex examples, Chelate effect.
Lecture 5-7	Valence bond theory, Crystal field theory, bonding in coordination compound for $d^1 – d^{10}$ system.
Lecture 8-10	Molecular orbital theory: Postulates, bonding & antibonding concept for sigma and pi-bonding complex (pi-donor and pi-acceptor ligands) octahedral and tetrahedral complex.
	UNIT II: Crystal Field Stabilization Energy
Lecture 1	Crystal field effect- (octahedral, tetrahedral, square pyramidal, trigonal bipyramidal
Lecture 2	High spin & low spin complex
Lecture 3-4	Crystal field stabilisation energy (CFSE) - d-orbital splitting in different geometries, factors affecting CFSE, applications of CFT
Lecture 5	Jahn-Teller distortion
Lecture 6	Spectrochemical series
Lecture 7	Nephelauxetic effect (Racah Parameter)
	UNIT III: Thermodynamic and kinetic aspects of coordination compound
Lecture 1-2	Introduction of reaction, kinetics and mechanism of tetrahedral, Square planar & Octahedral complex, Ligand substitution and electron transfer reaction of octahedral & square planar complexes, Trans effect.
Lecture 3-4	Association, dissociation and interchange substitution reaction mechanisms, Eigen–Wilkins mechanism,

Lecture 5-7	Mechanism of one electron reactions, Outer-sphere and inner sphere electron transfer reaction, type reactions, Marcus-Hush theory, factors depends on reaction mechanism.
	UNIT IV: Electronic spectra of transition metal complexes
Lecture 1-2	Introduction of electronic transitions of molecules and complexes, terminology for free atom & ions Term symbols, spectroscopic term symbols, Russell-Saunders coupling & J-J coupling/Spin-orbit coupling
Lecture 3	Selection rules (spin selection & laporte selection), d-d transition for various coordination complex
Lecture 4-5	Charge-transfer transition, metal-to-ligand charge transfer (MLCT) & LMCT (ligand-to-metal charge transfer e.g. dilute solution of $KMnO_4$)
Lecture 6	Orgel diagrams for octahedral and tetrahedral complex *e.g.* d^n-d^{10-n} for high and low spin complex
Lecture 7-8	Tanabe Sugano diagram octahedral and tetrahedral complex d^2, d^3, d^7, d^8 central metal electron system.
Lecture 9	Magnetic properties and measurements (Guoy an Faraday balance) of coordination compounds.
	UNIT V: Inner transition elements
Lecture 1	Introduction, Periodic trends of lanthanides and actinides
Lecture 2	Extraction & uses
Lecture 3-4	Physical properties- stable oxidation states, lanthanide and actinide contraction
Lecture 5	Lanthanide chelate, separations lanthanides from actinides
Lecture 6	Absorption spectra, luminescence of lanthanide complex, magnetic properties
Lecture 7	Inorganic compound & coordination compound of lanthanoids- halide, oxides, Ln(III) complex
Lecture 8-9	Thorium, Uranium & Plutonium inorganic compound & coordination compound of Actinoids

Name of Program	**M.Sc. Chemistry**
Name of Course	**Analytical Chemistry-I** **(Principles, Practices, and Applications)**
Course Code	**CY MS 514**
Core/ Elective/ Other	**Core**
Credit	**3**
Prerequisite: NIL	
1	Student should have understanding of the fundamentals of analytical chemistry.
2	Student should have the capability to understand how the advance knowledge could help in carrying out research.
Course Outcomes	
1	To impart basic knowledge in different concepts of analytical chemistry
2	The ability to explain basics of behind techniques like chromatography, electroanalytical methods, thermal methods etc.
Description of Contents in Brief In this course student will learn about phase diagrams and volumetric analysis based on Conductometer, potentiometer and pH metry; specific molar rotation using refractometer, phase diagrams based on three component system and Phase transition temperature.	
Detailed Syllabus	
1	**UNIT-I: Statistics and Data Handling in Analytical Chemistry** Characterizing Measurements and Results: Measures of Central Tendency (Mean & Median) and, Measures of Spread (Range, Standard Deviation & Variance); Characterizing Experimental Errors (Errors that affect Accuracy, Errors that affect Precision); Populations and Samples, Probability Distributions for Populations (Normal Distribution); Confidence Intervals for Populations, Degrees of Freedom, Confidence Intervals for Samples. Statistical Analysis of Data: Significance Testing, One-Tailed and Two-Tailed Significance Tests, Dixon's Q-Test
2	**UNIT-II: Separation Techniques** General theory of Separation, Classification of Separation Techniques based on size, mass or density, Complexing reagents (masking), change of state, Partitioning between Phases. Liquid-liquid extractions: Partition Coefficients and Distribution Ratios, Liquid–Liquid Extraction with no Secondary Reactions, Liquid–Liquid Extractions involving Acid–Base Equilibria, Liquid–Liquid Extraction of a Metal–Ligand Complex.
3	**UNIT-III: Advanced Chromatographic Techniques** General Theory of Column Chromatography (Chromatographic Resolution, Solute Retention Factor, Selectivity, Column Efficiency, Peak capacity,

	Asymmetric Peaks); Optimizing Chromatographic Separations (Using the Retention factor to optimize Resolution, Using Selectivity to optimize Resolution, Using Column Efficiency to optimize Resolution) Gas chromatography (Chromatographic Columns, Mobile phase, Sample Introduction, Temperature Control; Detectors: Thermal Conductivity Detector, Flame Ionization Detector, Electron Capture Detector, Mass Spectrometer); Quantitative and Qualitative Applications; Evaluation (Scale of Operation, Accuracy, Precision, Sensitivity, Selectivity, Time, Cost, and Equipment). High-Performance Liquid Chromatography (Columns, Mobile Phases, HPLC Plumbing; Detectors: Spectroscopic Detectors, Electrochemical Detectors); Quantitative and Qualitative Applications; Evaluation (Scale of Operation, Accuracy, Precision, Sensitivity, Selectivity, Time, Cost, and Equipment). Ion-Exchange Chromatography Size-Exclusion Chromatography
4	**UNIT-IV: Advanced Thermal Techniques** Introduction to Thermal Analysis, Brief history of Thermal Analysis, Basic Measurement Technology Thermogravimetric Analysis: Design and measuring principle, Sample preparation, performing measurements, Interpreting TGA Curves, TGA Evaluations, Applications. Differential Thermal Analysis: Measurement Principle, DTA Curves and Calculations Differential Scanning Calorimetry: Design and measuring principle, Sample preparation, performing measurements, Interpreting DSC curves, DSC evaluations, Measurements, Calibration and Adjustment, Applications. Brief of Polymers and use of Thermal Analysis to characterize Polymers.
5	**UNIT-V: Electroanalytical Techniques** Introduction, Classification and Electrical components Polarography: Principle, factors affecting current flow, Ilkovic equation, Half-wave potential, experimental set-up, Advantages, disadvantages and applications Pulse Polarography: Instrumentation, theory and applications Linear and cyclic voltammetry: Instrumentation, theory and applications Potentiometry: Instrumentation, theory and applications Ion-selective electrodes
List of Text Books	
1	Modern Analytical Chemistry, David Harvey, McGraw-Hill Higher Education, 1st Edition, 2000.
2	Skoog A., Holler F. J., Crouch S. R., Principles of Instrumental Analysis, 6th Edition, Brooks/Cole Cengage Learning, Belmont, CA, 2007
3	Christian, G.D., "Analytical Chemistry" 6th Ed. Wiley, 2008

List of Reference Books	
1	Ewing, G.W., "Instrumental Methods of Chemical Analysis", 5 th Ed. McGraw Hill, 2004
2	Analytical Chemistry- R. M. Verma
3	Fundamentals of Analytical Chemistry, Eighth Edition- Skoog; West; Holler; Crouch
Lecture Plan (about 42 lecture)	
Lecture No.	**Topic**
	UNIT I: Statistics and Data Handling in Analytical Chemistry
Lecture 1	Vocabulary of Analytical Chemistry, Objectives, The Analytical Process
Lecture 2	Characterizing Measurements and Results: Measures of Central Tendency (mean, median)
Lecture 3	Measures of Spread (Range, Standard Deviation, variance)
Lecture 4	Characterizing Experimental Errors (Errors That Affect Accuracy, Errors That Affect Precision)
Lecture 5	Populations and Samples
Lecture 6	Probability Distributions for Populations (Normal distribution)
Lecture 7	Confidence Intervals for Populations, Degrees of freedom, Confidence Intervals for Samples
Lecture 8	Statistical Analysis of Data: Significance Testing, One-Tailed and Two-Tailed
Lecture 9	Significance Tests
Lecture 10	Dixon's Q-Test
	UNIT II: Separation Techniques
Lecture 1	Liquid–Liquid Extraction with no Secondary Reactions
Lecture 2	General theory of separation
Lecture 3	Classification of separation techniques based on size, mass or density
Lecture 4	Classification of separation techniques based on complexing reagents (masking), change of state, Partitioning Between Phases
Lecture 5	Liquid-liquid extractions: Partition Coefficients and Distribution Ratios
Lecture 6	Liquid–Liquid Extractions involving Acid–Base Equilibria
Lecture 7-8	Liquid–Liquid Extraction of a Metal–Ligand Complex
	UNIT III: Advanced Chromatographic Techniques
Lecture 1	General Theory of Column Chromatography: Chromatographic Resolution, Solute Retention Factor
Lecture 2	Selectivity, Column Efficiency, Peak capacity, Asymmetric Peaks, Optimizing Chromatographic Separations: Using the Retention factor to Optimize Resolution
Lecture 3	Using Selectivity to Optimize Resolution, Using Column Efficiency to Optimize Resolution
Lecture 4	Gas chromatography: Chromatographic Columns,

	Mobile phase, Sample Introduction, Temperature Control
Lecture 5	Detectors: Thermal Conductivity Detector, Flame Ionization Detector, Electron Capture Detector, Mass Spectrometer
Lecture 6	Quantitative and Qualitative Applications, Evaluation (Scale of Operation, Accuracy, Precision, Sensitivity, Selectivity, Time, Cost, and Equipment)
Lecture 7	High-Performance Liquid Chromatography: Columns, Mobile Phases, HPLC Plumbing
Lecture 8	Detectors: Spectroscopic Detectors, Electrochemical Detectors Quantitative and Qualitative Applications
Lecture 9	Evaluation: Scale of Operation, Accuracy, Precision, Sensitivity, Selectivity, Time, Cost, and Equipment
Lecture 10	Ion-Exchange Chromatography Size-Exclusion Chromatography
	UNIT IV: Advanced Thermal Techniques
Lecture 1	Introduction to thermal analysis, brief history of thermal analysis, basic measurement technology
Lecture 2	Thermogravimetric analysis: Design and measuring principle, Sample preparation, performing measurements
Lecture 3	Interpreting TGA curves, TGA evaluations, Applications
Lecture 4	Differential thermal analysis: Measurement principle, DTA curves and calculations
Lecture 5	Differential scanning calorimetry: Design and measuring principle, sample preparation, performing measurements
Lecture 6-8	Interpreting DSC curves, DSC evaluations, Measurements, Calibration and adjustment, Applications. Brief of polymers and use of thermal analysis to characterize polymers
	UNIT V: Electroanalytical Techniques
Lecture 1	Electroanalytical Techniques: Introduction, Classification and Electrical components
Lecture 2	Polarography: Principle, factors affecting current flow, Ilkovic equation, Half-wave potential, experimental set-up, Advantages, disadvantages and applications
Lecture 3	Pulse Polarography: Instrumentation, theory and applications
Lecture 4-5	Linear and cyclic voltammetry: Instrumentation, theory and applications Potentiometry: Instrumentation, theory and applications
Lecture 6	Ion-selective electrodes

Name of Program		**M.Sc. Chemistry**
Name of Course		**Inorganic Chemistry Lab I**
Course Code		**CY MS 516**
Core / Elective / Other Core		**Core**
Credit		**1**
Prerequisite: NIL		
Course Outcomes: Students will be able to		
1.	To carry out their own experiment which helps them to gain practical skills in inorganic chemistry	
2.	Perform qualitative chemical analysis	
3.	Estimate cation & anion of inorganic compounds quantitively (volumetric & gravimetric)	
4.	Synthesize inorganic compound	
Description of Contents in Brief This course deals with inorganic chemistry practical of both qualitative and quantitative including synthesis.		
Detailed Syllabus		
1.	**Group Analysis** • Qualitative inorganic analysis	
2.	**Iodometric titration** • Iodometric titration for estimation of copper sulphate using sodium thiosulphate solution. • Iodometric titration for estimation of iodine in iodized common salt. • Estimation of MnO_2 in Pyrolusite.	
3.	**Complexometric titration using EDTA as a reagent** • Determination of Ca and Mg in Dolomite. • Determination of Nickel using murexide indicator.	
4.	**Synthesis** • Bis(acetylacetonato)diammamineiron(II) [Fe(acac)(en)Cl_2]. • Hexaminecobalt (III)chloride (any coordination compound).	
5.	**Gravimetry** • The gravimetric determination of copper as Cu(I)thiocyanate	
List of Text Books		
1.	Vogel's qualitative inorganic analysis, 7th edition, B Sivasankar; Pearson Publication	
2.	Vogel's quantitative chemical analysis, 6th edition, J Mendham; Pearson Publication	
3.	Practical Inorganic Chemistry, G. Marr and B. W. Rockett, Von Nostrand Reinhold Co., London	

Name of Program	**M.Sc. Chemistry**
Name of Course	**Inorganic Chemistry II:** **(Main Group elements and Group Theory)**
Course Code	**CY MS 522**
Core/ Elective / Other	**Core**
Credit	**3**
Prerequisite:	
1.	Basic mathematics of group and matrix.
Course Outcomes: Students are expected to	
1	Compare principles & theories of acid & base concepts
2	Inspect the concept of aqueous & non-aqueous solvent
3	Determine the symmetry element & symmetry operation of any simple molecule
4	Demonstrate point groups for finding out electronic properties of atom or molecule. Also, compare selection rules for various transitions.
Description of Contents in brief:	
First part of course will cover basic principles of theories and applications of acid and base, aqueous & non-aqueous solvent. Second part of the course covers symmetry of molecules and their applications.	
Detailed Syllabus:	
1	**UNIT I: Concepts of acids, bases and aqueous, non-aqueous solvents** Bronsted-Lowry, Lux-Flood, Solvent-system, Lewis, Usanovich, definition of acid and base, measures of acid & base strength, Arrhenius, Franklin, protonic acid-base theory, Hard-Soft acid-base theory, Classification of acid & base, electronegativity of hard & soft acid-base. Water, ammonia, protonic solvent, aprotic solvent molten salt- solvent properties, reactivity of molten salt, complex formation of molten salt, electrochemistry in nonaqueous solution.
2	**UNIT II: Main group element properties- I** Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of group-13, 14, 15 elements.
3	**UNIT-III: Main group element properties – II** Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of the group- 16, 17 & 18 elements.
4	**UNIT-IV: Group Theory** Introduction to symmetry, symmetry element, symmetry operation, Group theory, representation of group. Generation of symmetry operation from symmetry element, Point group analysis.
5	**UNIT-V: Matrix representation of Group**

	Group multiplication table, stereographic projection, Matrix representation of symmetry elements, Matrix representation of point group, Reducible & irreducible representation, Great Orthogonality theorem, construction Character table using GOT and application of fundamental molecule, Mulliken symbol, reduction formula, Chemical applications of group theory: symmetry adapted linear combination of atomic orbitals. Molecular vibration – normal modes & symmetry operation. Chemical applications of group theory: symmetry adapted linear combination of atomic orbitals (LCAO-MO); Construction of hybrid orbitals using symmetry aspects; Selection rules.
List of Text Books	
1	Chemical Applications of Group theory by F. Albert Cotton. Wiley Publisher
2	Inorganic Chemistry by F Albert Cotton, Geoffrey Wilkinson John Wiley Publisher
3	Symmetry and spectroscopy of molecules, K. Veera Reddy, New age Int. Publisher
	Inorganic Chemistry by D. F. Shiver, P W Atkins. Oxford Publisher
List of Text Books	
1	Chemical Applications of Group theory by F. Albert Cotton. Wiley Publisher
2	Inorganic Chemistry by F Albert Cotton, Geoffrey Wilkinson John Wiley Publisher
3	Symmetry and spectroscopy of molecules, K. Veera Reddy, New age Int. Publisher
4	Inorganic Chemistry by D. F. Shiver, P W Atkins. Oxford Publisher
List of Reference Books	
1.	D. M. Bishop, Group theory and Chemistry, Dover, 1989
Lecture Plan (about 42 Lectures):	
Lecture No.	**Topic**
	UNIT I: **Concepts of acids, bases and aqueous, non-aqueous solvents**
Lecture 1	Bronsted-Lowry, Lux-Flood, Solvent-system, definition of acid and base
Lecture 2	Lewis, Usanovich definition of acid and base, Measures of acid & base strength
Lecture 3	Arrhenius, Franklin, protonic acid-base theory, Hard-Soft acid-base theory
Lecture 4	Classification of acid & base, electronegativity of hard & soft acid-base
Lecture 5-6	Water, ammonia, protonic solvent, aprotic solvent molten salt- solvent properties
Lecture 7	Reactivity of molten salt, complex formation of molten salt
Lecture 8	Electrochemistry in nonaqueous solution
	UNIT II: Main group element properties- I
Lecture 1-2	Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of group-13 elements
Lecture 3-5	Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of group-14 elements
Lecture 6-7	Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of group-15 elements
	UNIT III: Main group element properties – II

Lecture 1-3	Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of the group- 16 elements
Lecture 4-5	Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of the group- 17 elements
Lecture 6-7	Structure, bonding and reactivity of halides, oxides, oxoacids, nitrides, and sulfide compounds of the group- 16, 17 & 18 elements
	UNIT IV: Group Theory
Lecture 1	Symmetry elements and symmetry operations: molecular symmetry
Lecture 2	Introduction to symmetry & Group theory
Lecture 3	Nomenclature for symmetry operations/ elements
Lecture 4-5	Proper axis of symmetry, Plane of symmetry, Center of symmetry/inversion center, Rotation–reflection axis or axis of improper rotations, Identity
Lecture 6-9	Molecular point group – point group, identification of molecular point group, low symmetry & high symmetry molecules, Cn, Dn & Sn type point group
	UNIT V: Matrix representation of Group
Lecture 1	Group multiplication table
Lecture 2	Matrix representation of symmetry elements, Matrix representation of point group, Reducible & irreducible representation
Lecture 3-4	Character of a representation, properties of Irreducible representation construction Character table using GOT: different point group
Lecture 5	Mulliken symbols for IRs
Lecture 6	Determination of translational & rotational symmetry species
Lecture 7	Standard reduction formula, Direct product
Lecture 8-9	Chemical applications of group theory: symmetry adapted linear combination of atomic orbitals (LCAO-MO)
Lecture 10-11	Construction of hybrid orbitals using symmetry aspects; Selection rules

Name of Program		**M.Sc. Chemistry**
Name of Course		**Inorganic Chemistry Lab II and Minor Project-II (Self Learning)**
Course Code		**CY MS 526**
Core / Elective / Other Core		**Core**
Credit		**2**
Prerequisite: NIL		
Course Outcomes: Students will be able to		
1.	To carry out their own experiment which helps them to gain practical skills in inorganic chemistry	
2.	Understand qualitative chemical analysis	
3.	Estimate the mixtures by colorimetric and gravimetric techniques	
Description of Contents in Brief This course deals with inorganic chemistry practical of both qualitative and quantitative including synthesis.		
Detailed Syllabus		
1.	**Quantitative Analysis-I** • Colorimetric estimation of Cr, Fe, Co, Cu, Mn & NH_4^+, PO_4^{3-} & NO_3^-	
2.	**Quantitative Analysis-II** • Metal ion estimation in a mixture of salt (both two & three) by Gravimetric estimation. ➢ Cu & Ni ➢ Cu, Ni & Zn ➢ Fe, Ni & Zn	
3.	**Qualitative Analysis** • Group Analysis of Inorganic ions.	
4.	**Synthesis of Inorganic Complexes:** • $Ni(DMG)_2$ • $[Co(NH_3)_6][Co(NO_2)_6]$ • $Fe_4[Fe(CN)_6]_3$ Prussian blue	
5.	**Gravimetry** • Gravimetric analysis of single elements- Ag and Fe	
List of Text Books		
1.	Vogel's qualitative inorganic analysis, 7th edition, B Sivasankar; Pearson Publication	
2.	Vogel's quantitative chemical analysis, 6th edition, J Mendham; Pearson Publication	
3.	Practical Inorganic Chemistry, G. Marr and B. W. Rockett, Von Nostrand Reinhold Co., London.	

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organometallic Chemistry**
Course Code	**CY MS 612**
Core / Elective / Other	**Core**
Credit	**3**
Prerequisite: NIL	
Course Outcomes: Students will able to	
1	Understand the synthesis & chemical reactivity of halides, oxoacid, nitride & sulphide of main group elements & apply the structure and bonding of similar new compounds.
2	Identify the basic principle of structure and bonding of ring, cage inorganic compounds
3	Illustrate organometallic compounds of carbonyl, cyclopentdienyl, metallocene complex
4	Classify the mechanism of homogeneous and heterogeneous organometallic catalysts
Description of Contents in Brief	
First part of this course covers advanced main group elements with selected compounds. Also, second part covers basic principles & mechanism and classification of catalyst which is used in the industrial synthesis process.	
Detailed Syllabus	
1	**UNIT I: Inorganic Rings and Cages** Introduction, Structure, bonding and reactivity of Rings – borazine, phosphazene and their derivatives, Cages – borides, carbides, boranes, Lipscomb's PSEPT model & Styx notation, Wade´s rule, carcarboranes, metalloboranes & metallocarboranes, silicones, silicates etc.
2	**UNIT II: Organometallics** Introduction, Synthesis, structure and bonding of organometallic compounds, Counting of Electrons, EAN & 18-electron rule, MO theory applied to organometallic compounds, metal-carbonyls, metal-olefin complexes, metal-metal bonds, Wade´s rule for organometallic clusters.
3	**UNIT III: Metal-carbene & carbyne complex** Metal-carbene, metal-carbyne complexes and metallocenes (Fe, Ru, Cr). Types of organometallic reactions: Oxidative Addition (Concerted, SN_2 & radical mechanisms), Reductive Elimination, 4-Center Reactions [2+2] Reactions, Migratory insertion, Migration *vs* Insertion, Ligand substitution.
4	**UNIT IV: Homogeneous catalysis**

	Terminologies in Catalysis, Hydrogenation of alkenes and other unsaturated compounds, Carbonylation Reaction (hydroformylation, hydrocarboxylation & hydrocyanation].
5	**UNIT V: Heterogeneous catalysis and fluxional molecules** Introduction of heterogeneous catalysis, Fischer Tropsch reaction, Ziegler-Natta polymerization, etc. Fluxional metal-metal bonded compounds and clusters.
List of Text Books	
1	Inorganic Chemistry – Principles of Structure and Reactivity, J. E. Huheey, Harper Collins, New York, 2001
2	Inorganic Chemistry, Garry L Meislar, 3rd edition.
3	Basic Organometallic Chemsitry – Concepts, Synthesis and Applications; B DGupta, A J Elias 2nd edition
4	D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, Oxford, 2000
5	F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, John Wiley & Sons, Inc., New York, 2009
6	Weller, T. Overton, J. Rourke and F. Armstrong, Inorganic Chemistry, 6th Edition, Oxford University Press, 2014. (South Asia Edition 2015)
List of Reference Books	
1	The Organometallic Chemistry of the transition metals by R.H. Crabtree. Wiley Interscience
Lecture Plan (about 42 Lectures):	
Lecture No.	**Topic**
	UNIT I: **Inorganic Rings and Cages**
Lecture 1-3	Introduction of inorganic rings and cages, structures and bonding of Ring – Borazine, Phosphazene and Phosphazene polymers, Heterocyclic inorganic ring
Lecture 4-7	Boron cage compound – boranes, carboranes, metallacarboranes, boride, carbides
Lecture 8	Lipscomb's Polyhedral Skeletal Electron Pair Theory - Wade´s rule, Styx notation (Boron hydride),
Lecture 9-10	Inorganic chains, catenation, heterocatenation, Silicate minerals, Intercalation chemistry
	UNIT II: Organometallics
Lecture 1	Introduction & history of Organometallics
Lecture 2-3	Effective Atomic number, 18-valence electron rule – counting by electron-donor pair & neutral-ligand method with examples.
Lecture 4-6	Molecular orbital theory of organometallic complex- Octahedral geometry with sigma & pi-bonding complex, Square planar complex

Lecture 7-8	Metal carbonyl complex – laboratory and industrial synthesis, structure and pi-bonding, reaction of metal carbonyls (e.g. disproportionation, nucleophilic, electrophilic, migratory insertion, etc.)
Lecture 9-10	Brief explanation of Metal Isocarbonyl complex & metal nitrosyl complex, synthesis and applications
Lecture 11	Metal olefin complex (alkene and alkyne), synthesis and typical chemical reactions (Umpolung, Pauson-Khand reaction), Grubb's and Schrock catalyst.
	UNIT III: Metal-carbene & carbyne complex
Lecture 1-2	Introduction and classification of Metal-carbene – Fisher & Schrock carbene: synthesis, reaction bonding & uses, Tebbe's reagent.
Lecture 3	Introduction and classification of Fisher & Schrock Metal-carbyne- synthesis, reaction, bonding & uses.
Lecture 4-6	Metallocene complexes (Fe, Ru, Cr) – sandwich & half sandwich structure: synthesis, properties & reaction. Ferrocene and its derivatives.
Lecture 7-10	Types of organometallic reactions with examples: Oxidative Addition (Concerted, SN_2 & radical mechanisms), Reductive Elimination, 4-Center Reactions [2+2] Reactions, Migratory insertion, comparison studies of Migration and Insertion reactions, Ligand substitution reactions.
	UNIT IV: Homogeneous catalysis
Lecture 1	Catalysis – terminology, Industrial importance of catalyst, metathesis and olefin oxidation, asymmetric synthesis.
Lecture 2	Hydrogenation alkenes and alkynes compounds, industrial synthesis and chemical reactivity.
Lecture 3-4	Introduction and broader concepts of carbonylation reaction (e.g. hydroformylation, hydrocarboxylation, hydrocyanation & hydrosilation)
Lecture 5-6	Monsantro, Cativa and Wacker process for acetic acid synthesis
	UNIT V: Heterogeneous catalysis
Lecture 1-2	Introduction of heterogeneous catalysis and applications of heterogeneous catalysis – Fischer Tropsch reaction, Ziegler-Natta catalyst.
Lecture 3	Fluxional metal-metal bonded compounds.
Lecture 4-5	Introduction of clusters, transition metal carbonyl cluster (dinuclear & multinuclear) LNCC & HNCC, carbide clusters,

Name of Program		**M.Sc. Chemistry**
Name of Course		**Inorganic Chemistry Lab III**
Course Code		**CY MS 616**
Core / Elective / Other Core		**Core**
Credit		**1**
Prerequisite: NIL		
Course Outcomes: Students will be able to		
1.	To carry out their own experiment which helps them to gain practical skills in inorganic chemistry	
2.	Conduct the chromatography separation technique of ions	
3.	Evaluate qualitative & quantitative analysis of mixtures.	
Description of Contents in Brief		
Detailed Syllabus:		
1.	**Quantitative analysis:** Gravimetric analysis of alloys; (i) Analysis of bronze. (ii) Analysis of German silver.	
2.	**Synthesis Metal-complexes and characterization using IR spectroscopy.** (i) Bis(acetylacetonato)copper(II) [$Cu(acac)_2$]. (ii) Bis(acetylacetonato)diaquacobalt(II) [$Co(acac)_2(H_2O)$]. (iii) Tris(8-hydroxyquinolinato)aluminium	
3.	**Chromatographic separation** Paper chromatographic separation of cations- Ag (I), Hg_2 (II), and Pb (II). Paper chromatographic separation of anions- Cl^-, Br^-, and I^-.	
4.	**Flame Photometry** To determine lithium/ sodium/ potassium in the given solution flame photometrically by calibration curve method	
List of Text Books:		
1.	Vogel's qualitative inorganic analysis, 7th edition, B Sivasankar; Pearson Publication	
2.	Vogel's quantitative chemical analysis, 6th edition, J Mendham; Pearson Publication	
3.	Practical Inorganic Chemistry, G. Marr and B. W. Rockett, Von Nostrand Reinhold Co., London	

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organic Chemistry I** (Basic Stereochemistry and Reaction Mechanism)
Course Code	**CY MS 513**
Core/ Elective/ Other	**Core**
Credit	**3**
Prerequisite:	
Knowledge of basic stereochemistry and reaction mechanisms of different organic compounds to predict the structure of the molecules.	
Course Outcome:	
1.	Developing knowledge of molecular interconvertions and predict symmetry elements for a given organic compound.
2.	To predict the stereochemistry and mechanism of aliphatic nucleophilic substitution reaction
3.	Knowledge to design of different substituted aromatic substrate for desired structure-activity relationship.
Description of Content in Brief:	
Conformational analysis, stereochemistry, method of reaction mechanism, aliphatic and aromatic electrophilic/nucleophilic substitution reactions.	
Detailed Syllabus:	
1.	**UNIT-I: Conformational analysis** Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity in acylic and cyclohexane systems. Elements of symmetry: chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, Optical activity due to chiral planes, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Asymmetric Synthesis: Principle and categories with specific examples of asymmetric synthesis including newer methods involving enzymatic and catalytic reactions, enantio and diastereoselective synthesis.
2.	**UNIT-II: Stereoselective Reactions** Cyclopropanation, hydroboration, catalytic hydrogenation, and metal ammonia reduction, stereoselective synthesis of (-) ephedrine and (+) φ-ephedrine. Stereospecific Reactions: Elimination of 2,3- dibromobutane densyl chloride(1,2-diphenyl-1-chloroethane), S_N2 reactions at chiral carbon.
3.	**UNIT-III: Structure and Reactivity** Thermodynamic and kinetic requirements and control. Hammond postulate, Curtin-Hammett principle, potential energy diagrams, transition states and intermediates. Effect of structure on reactivity: resonance, field and steric

	effects. Quantitative treatment: Hammett equation and linear free energy relationship, Substituent and reaction constants, Taft equation and methods of determining reaction mechanism.
4.	**UNIT-IV: Nucleophilic Substitution Reactions** The S_N2, S_N1 mixed S_N2, S_N1 reactions, SET mechanisms & SNi mechanism. The neighboring group mechanism, neighboring group participation by π and σbonds, anchimeric assistance. Non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements- Wagner-Meerwein, Pinacol-Pinacolone and Demjanov ring expansion and ring contraction. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Esterification of carboxylic acid, transesterification, transetherification and preparation of inorganic esters. Phase-transfer catalysis and regioselectivity.
5.	**UNIT-V: Electrophilic Substitution reactions** Bimolecular mechanisms- SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts, halogenation of aldehydes, ketones, acids and acyl halides. Effect of substrates, leaving group and the solvent system on reactivity. Aliphatic diazonium coupling, Acylation at aliphatic carbon, alkylation of alkene, Stork-enamine reactions.
List of Books:	
1.	March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure 2020 by Michael B. Smith, 8th Edition.
2.	Organic Chemistry 8th Edition by Giuliano, Carey, 2012.
3.	Kleins Organic Chemistry 3rd Global Edition 2018 by Klein D R, John Wiley.
4.	Advanced Organic Chemistry: Part A: Structure and Mechanisms, 5th Edition, 20 June 2008 by Francis A. Carey, Richard J. Sundberg.
5.	Problems & Solutions: Advanced Organic Reaction Mechanism, 3rd Edition, 2011, Nimai Tewari.
6.	March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure 2020 by Michael B. Smith, 8th Edition.
Lecture Plan (about 42 Lectures):	
Lecture No.	**Topic**
	UNIT I: Conformational analysis
Lecture 1	Conformational analysis of cycloalkanes, decalins
Lecture 2	Effect of conformation on reactivity in acylic and cyclohexane systems
Lecture 3	Steric strain due to unavoidable crowding
Lecture 4	Elements of symmetry: chirality, molecules with more than one chiral center
Lecture 5	Threo and erythro isomers, methods of resolution
Lecture 6	Optical purity, enantiotopic and diastereotopic atoms, groups and faces
Lecture 7-8	Optical activity due to chiral planes, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape

Lecture 9	Asymmetric Synthesis: Principle and categories with specific examples of asymmetric synthesis including newer methods involving enzymatic and catalytic reactions
Lecture 10	Enantio and diastereoselective synthesis
	UNIT II: Stereoselective Reactions
Lecture 1	Cyclopropanation
Lecture 2	Hydroboration
Lecture 3	Catalytic hydrogenation, and metal ammonia reduction
Lecture 4	Stereoselective synthesis of (-) ephedrine and (+) φ- ephedrine
Lecture 5	Stereospecific Reactions: Elimination of 2,3- dibromobutane densyl chloride(1,2-diphenyl-1-chloroethane)
Lecture 6	S_N2 reactions at chiral carbon
	UNIT III: Structure and Reactivity
Lecture 1	Thermodynamic and kinetic requirements and control.
Lecture 2-3	Effect of structure on reactivity: resonance, field and steric effects
Lecture 4-5	Quantitative treatment: Hammett equation and linear free energy relationship
Lecture 6	Substituent and reaction constants
Lecture 7	Taft equation
Lecture 8-9	Methods of determining reaction mechanism
	UNIT IV: Nucleophilic Substitution Reactions
Lecture 1	Nucleophilic substitution reaction (S_N2, S_N1, mixed S_N1 and S_N2).
Lecture 2	SET mechanisms & S_Ni mechanism
Lecture 3	Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon
Lecture 4	The neighboring group mechanism, neighboring group participation by π and σ bonds, anchimeric assistance
Lecture 5	Non-classical carbocations, phenonium ions, norbornyl system
Lecture 6	Common carbocation rearrangements-Wagner-Meerwein
Lecture 7	Pinacol-Pinacolone and Demjanov ring expansion and ring contraction
Lecture 8	Esterification of carboxylic acid, transesterification, transetherification and preparation of inorganic esters
Lecture 9	Phase-transfer catalysis
Lecture 10	Ultrasound, ambident nucleophile, regioselectivity
	UNIT V: Electrophilic Substitution reactions
Lecture 1	Bimolecular mechanisms- S_E2 and S_Ei
Lecture 2	S_E1 mechanism
Lecture 3	Electrophilic substitution accompanied by double bond shifts
Lecture 4	Halogenation of aldehydes, ketones
Lecture 5	Halogenation of acids and acyl halides

Lecture 6	Effect of substrates, leaving group and the solvent system on reactivity
Lecture 7	Aliphatic diazonium coupling, Acylation at aliphatic carbon, alkylation of alkene, Stork-enamine reactions

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organic Chemistry Lab I**
Course Code	**CY MS 517**
Core / Elective / Other Core	**Core**
Credit	**1**
Prerequisite:	
1.	Basic knowledge of experimental organic techniques.
Course Outcomes: The students are expected to be able to:	
1.	To perform experiments and recognize the principles and techniques involved in chemical experimentation.
2.	To acquire experimental skills & handling instruments.
3.	Knowledge in prediction & verification of experimental results by graphical method.
Description of Contents in brief: Functional group analysis, Synthesis of Organic compound and preparations.	
Detailed Syllabus:	
1.	Isolation and identification of tannic acid in tea samples.
2.	Determination of casein and lactose contents in a given milk sample.
3.	Estimation of acetic acid in commercial vinegar solutions.
4.	Estimation of Oxalate content in natural product (spinach).
5.	Functional group analysis of hydrocarbons in a given organic sample.
6.	Identification of functional compounds and synthesis of their derivatives in a given mixture.
7.	Synthesis of anthranilic acid from phthalic anhydride.
8.	Synthesis of p-nitroaniline acid derivatives.
9.	Synthesis of p-nitroacetanilide and its derivatives.
10.	Preparation of adipic acid using greener approaches.
List of Text Books:	
1.	Vogels Textbook of Practical Organic Chemistry 5Th Edition by Furniss and Brian S and Hannaford and Antony J, Pearson, 2016
2.	Advanced Practical Organic Chemistry 2010 by N.K. Vishnoi, 3rd Edition.
3.	Practical Organic Chemistry, 4th edition, 2009 by Mann & Saunders.

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organic Chemistry II** (Heterocyclic Compounds and Organic Reagents)
Course Code	**CY MS 523**
Core/ Elective/ Other	**Core**
Credit	**3**
Prerequisite:	
Knowledge of the nomenclature of heterocyclic and aromatic compounds.	
Course Outcome:	
1.	To develop the understanding of different heterocyclic compounds for organic transformations.
2.	Knowledge of aromatic and non-aromatic compounds to distinguish different chemical applications for academic and industrial relevance.
3.	Overall structural and mechanistic recognition of important organic named reactions.
Description of Content in Brief:	
Concept of Aromaticity, Aromaticity of five-membered, six-membered rings and fused systems- Non-benzonoid aromatic compounds. Named reactions for the synthesis of multiple carbon-carbon bond formation.	
Detailed Syllabus:	
1.	**Concept of Aromaticity:** Aromaticity of five-membered, six-membered rings and fused systems- Non-benzonoid aromatic compounds: cyclopropenylcation, Cyclobutadienyldication, cyclopentadienyl anion-tropyllium cation and cyclooctatetraenyl dianion. Homoaromaticity, Anti aromaticity and pseudo aromaticity.
2.	**Nomenclature of Heterocyclic Compounds:** Systematic (Hantzsch-Widman) nomenclature for monocylic and fused ring systems. Methods of synthesis and Reactions including mechanism of the following five-membered 1,2- and 1,3-heterocycles: pyrazole, imidazole, oxazole, isooxazole, thiazole, isothiazole; their basic character. Methods of synthesis and reactions including mechanism of the following six-membered heterocycles: purines and pyrimidines.
3.	**Organometallic Reagents in Organic Synthesis:** Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of Li, Mg, Cd, Zn, Cu, S, Si, B and I metals in organic synthesis.
4.	**Oxidation of Organic Compounds:** Introduction of different oxidative processes, Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and unactivated). Alcohols, diols, aldehydes, ketones, ketals and

	carboxylic acids. Amines, hydrazines, and sulphides. Oxidations with ruthenium tetraoxide, and thallium (III) nitrate.
5.	**Reduction of Organic Compounds:** Introduction of different reductive processes. Hydrocarbons– alkanes, alkenes, alkynes and aromatic rings. Carbonyl compounds-aldehydes, ketones, acids and their derivatives. Epoxides. Nitro, nitroso, azo and oxime groups. Hydrogenolysis.
List of Books:	
1.	Organic Chemistry. 6th Edition 2016 by Robert T. Morrison, Robert N. Boyd.
2.	Organic Chemistry: Structure Mechanism Synthesis. 2nd Edition 2018 by J. David Rawn, Robert J. Ouellette, Acad Pr.
3.	Organic Chemistry: Structure and Function. 8th Edition, 2018, Peter Vollhardt.
Lecture Plan (About 42 lectures)	
Lecture No.	**Topic**
	UNIT I: Concept of Aromaticity
Lecture 1	Concept of Aromaticity, Aromaticity of five membered and six membered rings
Lecture 2	Fused systems - Non-benzonoid aromatic compounds: cyclopropenylcation
Lecture 3-4	Cyclobutadienyldication, cyclopentadienyl anion-tropyllium cation and cyclooctatetraenyl dianion
Lecture 5	Problems based on aromaticity
Lecture 6	Homoaromaticity, Anti aromaticity, pseudo aromaticity
Lecture 7	Applications of aromatic compounds
	UNIT II: Nomenclature of Heterocyclic Compounds
Lecture 1	Systematic (Hantzsch-Widman) nomenclature for monocylic and fused ring systems.
Lecture 2-3	Methods of synthesis and Reactions including mechanism of the following five-membered 1,2- and 1,3-heterocycles: pyrazole, imidazole, oxazole
Lecture 4-5	Methods of synthesis and Reactions including mechanism of the following five-membered 1,2- and 1,3-heterocycles: isooxazole, thiazole, isothiazole
Lecture 6	Methods of synthesis and reactions including mechanism of the following six-membered heterocycles: purines
Lecture 7	Methods of synthesis and reactions including mechanism of the following six-membered heterocycles: pyrimidines
	UNIT III: Organometallic Reagents in Organic Synthesis
Lecture 1	Principle and preparations, properties and applications and mechanistic details of the organometallic reagents of Li metal in organic synthesis
Lecture 2	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of Mg metal in organic synthesis

Lecture 3	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of Cd metal in organic synthesis
Lecture 4	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of Zn metal in organic synthesis
Lecture 5	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of Cu metal in organic synthesis
Lecture 6	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of S in organic synthesis
Lecture 7	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of Si in organic synthesis
Lecture 8	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of B in organic synthesis
Lecture 9	Principle, preparations, properties and applications and mechanistic details of the organometallic reagents of I in organic synthesis
	UNIT IV: Oxidation of Organic Compounds
Lecture 1	Introduction of different oxidative processes
Lecture 2-4	Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and unactivated)
Lecture 5	Alcohols, diols
Lecture 6-7	Aldehydes, ketones, ketals and carboxylic acids
Lecture 8-9	Amines, hydrazines, and sulphides
Lecture 10	Oxidations with ruthenium tetraoxide
Lecture 11	Oxidations with thallium (III) nitrate
	UNIT V: Reduction of Organic Compounds
Lecture 1	Introduction of different reductive processes
Lecture 2-3	Hydrocarbons– alkanes, alkenes, alkynes and aromatic rings
Lecture 4-5	Carbonyl compounds-aldehydes, ketones, acids and their derivatives
Lecture 6	Epoxides
Lecture 7	Nitro, nitroso, azo and oxime groups
Lecture 8	Hydrogenolysis

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organic Chemistry Lab II**
Course Code	**CY MS 527**
Core / Elective / Other Core	**Core**
Credit	**1**
Prerequisite:	
Basic principles of chromatographic techniques.	
Course Outcomes:	
1.	To obtain knowledge of experimental chromatic techniques.
2.	To interpret the experimental data for organic applications
3.	To obtain knowledge of binary organic mixture analysis
Description of Contents in Brief:	
Chromatography, Organic Preparation and Quantitative analysis	
Detailed Syllabus:	
1.	To separate the given mixture of Amino acids by Paper chromatography.
2.	Separation and identification of Sugars by Thin layer chromatography.
3.	Separation of Pigments from the extracts of Spinach Leaves by Column chromatography.
4.	To separate the dyes used in nail paint by the Paper chromatography method.
5.	To prepare aspirin (acetylsalicylic acid) from salicylic acid.
6.	Preparation of adipic acid
7.	To prepare 2, 4, 6-trinitrophenol from phenol.
8.	Synthesis of Soap
9.	Synthesis of Methyl-orange
10.	Estimation of glucose and glycine
List of Text Books:	
1.	Vogels Textbook of Practical Organic Chemistry 5th Edition by Furniss and Brian S and Hannaford and Antony J, Pearson, 2016
2.	Advanced Practical Organic Chemistry 2010 by N. K. Vishnoi, 3rd Edition.
3.	Chromatography: Basic Principles, Sample Preparations and Related Methods Paperback – Illustrated, 3rd Edition, 2013 by Elsa Lundanes , Léon Reubsaet, Tyge Greibrokk

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organic Spectroscopy and Pericyclic Reactions**
Course Code	**CY MS 613**
Core/ Elective/ Other	**Core**
Prerequisite:	
Basic knowledge of spectroscopic principles and photochemical reactions.	
Course Outcome:	
1.	To develop understanding of different spectroscopic techniques for the determination of structure.
2.	To develop the knowledge of basic instrumentation and working principles of different spectroscopic techniques.
3.	To interpret spectroscopic data (UV, IR. NMR and Mass spectroscopy) for complete structural analysis.
4.	To develop the knowledge of concerted organic reactions and organic photochemistry.
5.	To interpret pericyclic reactions governed by Woodward-Hoffmann rules.
6.	To understand the synthetic applications and mechanisms of various photochemical reactions.
Description of Content in Brief:	
1.	Spectroscopic Methods in Structure Determination, IR spectroscopy, Ultraviolet and Visible Spectroscopy, Nuclear Magnetic Resonance Spectroscopy.
2.	Calculation of Quantum yield, electronic states and transitions of organic compounds. Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron systems and sigmatropic rearrangements.
Detailed Syllabus:	
1.	**IR spectroscopy**: Introduction – basic theory and instrumentation including FT IR infrared spectrum. Functional group and fingerprint regions. Absorption of infrared radiation and molecular vibrations. Fundamental vibrations and overtones. Intensity and position of infrared absorption bands, bands resulting from combination or difference of vibrational frequencies or by the interaction of overtones (or combination bands) with the fundamental vibrations (fermi resonance). Frequency of vibrations of a diatomic molecule, spectral features of major functional group. Effect of hydrogen bonding and solvent effect on vibrational frequencies, combination bands and Fermi resonance. Applications of IR spectroscopy in organic compounds.
2.	**Nuclear Magnetic Resonance Spectroscopy**: Introduction – spin active nuclei behave as spinning nuclear magnets, orientation of spinning nuclear magnets in a uniform magnetic field. Phenomenon of resonance and

	relaxation, chemical shift , chemical shift parameters and internal standards, factors affecting the chemical shift: shielding and deshielding of a nucleus, substitution effects leading to empirical co-relations for proton chemical shifts, anisotropic effect, effect of changing solvents, effect of hydrogen bonding, influence of chirality on the chemical shifts of enantiomers and intermolecular Vander Walls deshielding, spin spin coupling, multiplicity of splitting and relative intensity of lines in a multiplet, integration, mechanism of coupling of one bond, two bonds and three bonds coupling. Nuclear Overhauser effect (NOE). Effect of sensitivity of C- 13 NMR compared to H–1 NMR, comparison of C–13 NMR and H-1NMR, chemical shifts of C–13 NMR. Simplification of C – 13 spectra by process of decoupling, off-resonance decoupling.
3.	**Ultraviolet, Visible Spectroscopy and Mass Spectroscopy:** Electronic energy levels, electronic transitions and selection rules. The origin, general appearance and designation of UV bands, absorption laws and measurement of absorption intensity, chromophores, auxochromes, bathochromic shift, hypochromic shift, hypochromic effect, hyperchromic effect. Woodward and Fieser's rules for calculating ultraviolet absorption maxima for substituted dienes and conjugated dienes, unsaturated carbonyl compounds and aromatic carbonyl compounds. Introduction – basic theory, instrumentation, the process of introducing the sample into the mass spectrometer. Methods of generation of positively charged ions, electron ionization method, chemical ionization, FD and fast atom bombardment (FAB) techniques. Mass spectrum, base peak, molecular and parent ion, Mass to charge ratio (M/Z), relative intensity, fragment ions, even electron rule, nitrogen rule, metastable ions, McLafferty rearrangement and ortho effect. Determination of molecular weight and molecular formula using mass spectrometry. Problems based on joint application of UV, IR, PMR, CMR, and Mass spectroscopy.
4.	**Principles of Photochemistry**: Quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process. Photochemistry of carbonyl compounds: $\pi' \pi^*$, $n' \pi^*$ transitions, Norrish-I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction. Photochemistry of olefins: cis-trans

	isomerizations, dimerizations, hydrogen abstraction, addition and Di- π-methane rearrangement including aza-di- π –methane.
5.	**Cycloaddition Reactions:** 4nπ and (4n+2)π electron systems. Diels-Alder reactions, 1, 3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, site selectivity and effect of substituents in Diels-Alder reactions. Electrocyclic reactions: Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron systems. Sigmatropic rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations. Cope (including oxy-Cope and aza-Cope) and Claisen rearrangements. Formation of Vitamin D from 7-dehydrocholestrol, synthesis of citral using pericyclic reaction.
List of Books:	
1.	Introduction to Spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 5th Edition. (Harcourt college publishers). 2015
2.	Spectrometric identification of organic compounds R. M. Silverstein, F. X. Webster, 8th Edition. John Wiley and Sons. ISBN: 9780470616376, 9780470616376
3.	Spectroscopic Methods In Organic Chemistry by Fleming Ian Williams Dudley, Springer, 7th Edition 2020.
4.	Nuclear Magnetic Resonance – Basic Principles- Atta-Ur-Rehman, Springer- Verlag, ISBN: 9788181288738, 9788181288738.
5.	Organic Spectroscopy. 2019 by KEMP W. 2nd Edition.
6.	Advanced Organic Chemistry: Part B: Reaction and Synthesis, 5th Edition June 2008 by Francis A. Carey, Richard J. Sundberg.
7.	Advanced Organic Chemistry-Reactions & Mechanics. 2nd Edition by Pearson, 2021.
8.	A Guidebook to Mechanism in Organic Chemistry by Peter Sykes, 2nd Edition, 2013.
9.	Synthetic approaches in organic chemistry by R.K. Banal (Narosa Publications), 5th Edition 2016.
10.	Advanced Organic Chemistry: Part B: Reaction and Synthesis, 5th Edition June 2008 by Francis A. Carey, Richard J. Sundberg.
Lecture Plan (about 42 lectures)	
Lecture No.	**Topic**
	UNIT I: IR spectroscopy
Lecture 1	IR spectroscopy: Introduction – basic theory and instrumentation including FT IR spectrum
Lecture 2-3	Functional group and fingerprint regions, Absorption of infrared radiation and molecular vibrations, Fundamental vibrations, and overtones
Lecture 4	Intensity and position of infrared absorption bands, bands resulting from combination or difference of vibrational frequencies or by the interaction of overtones (or combination bands) with the fundamental vibrations (fermi resonance)
Lecture 5	Frequency of vibrations of a diatomic molecule, spectral features of major functional groups: alkanes, alkenes, alkynes, aromatic compounds

Lecture 6	Frequency of vibrations of a diatomic molecule, spectral features of major functional groups: alcohols, ethers, phenols, ketones, aldehydes, esters
Lecture 7	Frequency of vibrations of a diatomic molecule, spectral features of major functional groups: amides, acids, anhydrides, lactones, lactams, conjugated carbonyl compounds and amines
Lecture 8	Effect of hydrogen bonding and solvent effect on vibrational frequencies
Lecture 9	Overtones, combination bands and fermi resonance. Applications of IR spectroscopy
	UNIT II: Nuclear Magnetic Resonance Spectroscopy
Lecture 1	Introduction – spin active nuclei behave as spinning nuclear magnets
Lecture 2	Orientation of spinning nuclear magnets in a uniform magnetic field and energy description of NMR phenomenon
Lecture 3	Continuous wave (CW) NMR spectrometer and Fourier transform (FT) NMR spectrometer
Lecture 4	Phenomenon of resonance and relaxation, chemical shift , chemical shift parameters and internal standards
Lecture 5	Factors affecting the chemical shift: shielding and deshielding of a nucleus, substitution effects leading to empirical co-relations for proton chemical shifts
Lecture 6	The anisotropic effect, effect of changing solvents, the effect of hydrogen bonding, Influence of chirality on the chemical shifts of enantiomers and intermolecular Vander Walls deshielding
Lecture 7	Spin spin coupling, multiplicity of splitting and relative intensity of lines in a multiplet, integration, Mechanism of coupling-one bond coupling (1J), two bond coupling (2J) three bond coupling (3 J) including Karplus relationship
Lecture 8	Techniques for simplification of complex spectra: solvent effects, Lanthanide shift reagents, spin decoupling (double resonance)
Lecture 9	Fourier Transform technique, Nuclear Overhauser effect (NOE), Effect of sensitivity of C- 13 NMR compared to H–1 NMR
Lecture 10	Comparison of C–13 NMR and H-1NMR, chemical shifts of C–13 NMR, Simplification of C – 13 spectra by process of decoupling, off-resonance decoupling
	UNIT III: Ultraviolet, Visible Spectroscopy and Mass Spectroscopy
Lecture 1	Electronic energy levels, electronic transitions, and selection rules.
Lecture 2	The origin, general appearance and designation of UV bands, absorption laws and measurement of absorption intensity
Lecture 3	Chromophores, auxochromes, bathochromic shift, hypochromic shift, hypochromic effect, hyperchromic effect

Lecture 4-5	Woodward and Fieser's rules for calculating ultraviolet absorption maxima for substituted dienes and conjugated dienes, unsaturated carbonyl compounds and aromatic carbonyl compounds
Lecture 6	Introduction – basic theory, instrumentation, the process of introducing the sample into the mass spectrometer
Lecture 7-8	Methods of generation of positively charged ions, electron ionization method, chemical ionization, FD and fast atom bombardment (FAB) techniques
Lecture 9	Mass spectrum, base peak, molecular and parent ion, Mass to charge ratio (M/Z), relative intensity, fragment ions, even electron rule, nitrogen rule, metastable ions, McLafferty rearrangement and ortho effect
Lecture 10	Determination of molecular weight and molecular formula using mass spectrometry
Lecture 11	Problems based on joint application of UV, IR, PMR, CMR, and Mass spectroscopy
	UNIT IV: Principles of Photochemistry
Lecture 1	Quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process
Lecture 2	Photochemistry of carbonyl compounds: $\pi^{\prime}\pi^{*}$, $n^{\prime}\pi^{*}$ transitions, Norrish-I and Norrish-II cleavages
Lecture 3	Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones
Lecture 4	Photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction
Lecture 5	Photochemistry of olefins: cis-trans isomerizations, dimerizations, hydrogen abstraction
Lecture 6	Addition and Di- π- methane rearrangement including aza-di- π –methane
	UNIT V: Cycloaddition Reactions
Lecture 1-2	4nπ and (4n+2)π electron systems. Diels-Alder reactions, 1, 3-Dipolar cycloaddition and cheletropic reactions
Lecture 2-3	Ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, site selectivity and effect of substituents in Diels-Alder reactions
Lecture 4	Electrocyclic reactions: Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron systems
Lecture 5-6	Sigmatropic rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations

Name of Program	**M.Sc. Chemistry**
Name of Course	**Natural Products and Medicinal Chemistry**
Course Code	**CY MS 614**
Core/ Elective/ Other	**Core**
Credit	**3**
Prerequisite:	
Knowledge of natural products for their potential role in the development of pharmaceutical drugs for several diseases.	
Course Outcome:	
1.	Understanding of natural products chemistry for living organisms. Research can help.
2.	Improving the understanding of biological processes to identify compounds that may lead to the development of new drugs.
Description of Content in Brief:	
Terpenoids and Carotenoids, Alkaloids and Steroids, Carbohydrates, Proteins and Nucleic acids, Pharmacodynamics, Antifungal and Antimalarial.	
Detailed Syllabus:	
1.	**Terpenoids and Carotenoids:** Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol α-Terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-Carotene.
2.	**Alkaloids and Steroids:** Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, and classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine and Morphine. Occurrence, nomenclature, basic skeleton, Structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone, Aldosterone, and Biosynthesis of Steroids.
3.	**Plant Pigments:** Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Luteolin Quercetin, Myrcetin, Quercetin 3-glucoside, Vitexin, Diadzein, Aureusin, Cyanidin-7arabinoside, Cyanidin, Hirsutidin, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway; Prophyrins: Structure and synthesis of Hemoglobin and Chlorophyll

4.	**Pharmacodynamics:** Introduction, elementary treatment of enzymes stimulation, enzyme inhibition, sulfonamides, membrane-active drugs, drug metabolism, xenobiotics, biotransformation, significance of drug metabolism in medicinal chemistry. Antibiotics and antibacterials: Introduction, Antibiotic β-Lactam type- Penicillins, Cephalosporins, Antitubercular, Streptomycin, Broad spectrum antibiotics. Tetracyclines, Anticancer- Dactinomycin (Actinomycin D).
5.	**Antifungal and Antimalarial Agents:** Antifungal: Polyenes, Antibacterial: Ciprofloxacin, Norfloxacin, Antiviral. Acyclovir Antimalarials: chemotherapy of malaria. SAR. Chloroquine, Chloroguanide and Mefloquine. Non-steroidal Anti-inflammatory Drugs: Diclofenac Sodium, Ibuprofen and Netopam.
List of Books:	
1.	Burger's Medicinal Chemistry Drug Discovery and Development, Vol. 8th 2021
2.	The Chemistry of Natural Products by R H Thomson, 2nd Edition, 2008
3.	Natural Products: The Secondary Metabolites (Tutorial Chemistry Texts) by James R Hanson and Martyn Berry. Volume 17, 2003.
4.	Natural Product Chemistry (Prof. Mayuresh K. Raut, Prof. Raju R. Wadekar), 1st Edition, 2017.
5.	An Introduction to Medicinal Chemistry by Graham L. Patrick, 4th Edition.
6.	Lehninger Principles of Biochemistry. 8th International Edition 2021 by David L. Nelson.
7.	Wilson And Gisvolds Textbook Of Organic Medicinal And Pharmaceutical Chemistry 12 Rep.by John M Beale. 12th Edition 2017.
8.	Burger's Medicinal Chemistry Drug Discovery and Development, Vol. 8th 2021.
Lecture Plans (About 42 lectures)	
Lecture No.	**Topic**
	UNIT I: Terpenoids and Carotenoids
Lecture 1	Classifications, nomenclature, occurrence of terpenoid
Lecture 2	Classifications, nomenclature, occurrence of carotenoid
Lecture 3	Isolation, general methods of structure determination
Lecture 4	Isoprene rule
Lecture 5-6	Structure determination and synthesis of Citral, Geraniol α-Terpeneol
Lecture 7-8	Structure determination and synthesis of Menthol, Farnesol, Zingiberene
Lecture 9-10	Structure determination and synthesis of Santonin, Phytol, Abietic acid and β-Carotene
	UNIT II: Alkaloids and Steroids
Lecture 1	Definition, nomenclature and physiological action, occurrence of Alkaloid
Lecture 2	Isolation, general methods of structure elucidation, degradation, and classification based on nitrogen heterocyclic ring

Lecture 3	Structure, stereochemistry, synthesis and biosynthesis of Ephedrine, Coniine, Nicotine
Lecture 4	Structure, stereochemistry, synthesis and biosynthesis of Ephedrine, Coniine, Nicotine
Lecture 5	Structure, stereochemistry, synthesis and biosynthesis of Atropine, Quinine and Morphine
Lecture 6	Steroids: Occurrence, nomenclature, basic skeleton
Lecture 7	Structure determination and synthesis of Cholesterol, Bile acids
Lecture 8	Structure determination and synthesis of Androsterone, Testosterone
Lecture 9	Structure determination and synthesis of Estrone, Progesterone, Aldosterone
Lecture 10	Biosynthesis of Steroids
	UNIT III: Plant Pigments
Lecture 1	Occurrence, nomenclature and general methods of structure determination
Lecture 2	Isolation and synthesis of Apigenin, Luteolin Quercetin
Lecture 3	Isolation and synthesis of Myrcetin, Quercetin 3-glucoside
Lecture 4	Isolation and synthesis of Vitexin, Diadzein, Aureusin
Lecture 5	Isolation and synthesis of Cyanidin-7arabinoside, Cyanidin, Hirsutidin
Lecture 6-7	Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway
Lecture 8	Porphyrins: Structure and synthesis of Hemoglobin and Chlorophyll
	UNIT IV: Pharmacodynamics
Lecture 1	Introduction, elementary treatment of enzymes stimulation
Lecture 2	Enzyme inhibition
Lecture 3	Sulfonamides
Lecture 4	Membrane active drugs
Lecture 5	Drug metabolism
Lecture 6	Xenobiotics
Lecture 7	Biotransformation
Lecture 8	Significance of drug metabolism in medicinal chemistry
Lecture 9	Antibiotics and antibacterials: Introduction, Antibiotic β-Lactam type-Peninillins, Cephalosprins, Streptomycin, Broad spectrum antibiotics.
Lecture 10	Tetracyclines, Anticancer- Dactinomycin (Actinomycin D)
	UNIT V: Antifungal and Antimalarial Agents
Lecture 1	Antifungal: Polyenes, Antibacterial: Ciprofloxacin, Norfloxacin
Lecture 2	Antiviral. Acyclovir, Antimalarials: chemotherapy of malaria
Lecture 3	SAR. Chloroquine, Chloroguanide and Mefloquine.
Lecture 4	Non-steroidal Anti-inflammatory Drugs: Diclofenac Sodium, Ibuprofen and Netopam.

Name of Program	**M.Sc. Chemistry**
Name of Course	**Organic Chemistry Lab III and Minor Project-III** *(Self-Learning)*
Course Code	**CY MS 617**
Core / Elective / Other Core	**Core**
Credit	**2**
Prerequisite:	
Basic Organic Chemistry Laboratory and spectroscopic techniques.	
Course Outcomes:	
1.	Understanding of designing chromatographic experimental results.
2.	Knowledge of separating techniques
3.	Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.
4.	Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
Description of Contents in Brief:	
Extraction, Synthesis, and Interpretation of spectra.	
Detailed Syllabus:	
1.	Extraction of citric acid (from lemon and orange)
2.	Piperine from black pepper
3.	Extraction of lycopene from tomato and DNA extraction from onions.
4.	Paracetamol in tablet from spectroscopic method.
5.	Extraction of menthol from mint leaves and identification of functional groups.
6.	Separation, purification, and identification of compounds of binary mixtures by chemical tests.
7.	Identification of individual compounds by spectroscopic analysis (IR, NMR etc.)
8.	Purification of individual components using TLC technique and confirmation my melting points.
9.	Synthesis of Coumarin and their derivatives. Identification of the structure by spectroscopic analysis.
10.	Synthesis of Cinnamic acid by Perkin's reaction.
11.	Synthesis of 2,5-dihydroxy acetophenone from hydroquinone.
List of Text Books:	
1.	Vogels Textbook of Practical Organic Chemistry 5Th Edition by Furniss and Brian S and Hannaford and Antony J, Pearson, 2016.
2.	Advanced Practical Organic Chemistry 2010 by N.K. Vishnoi, 3rd Edition.
3.	Introduction to Experimental Infrared Spectroscopy, John Wiley & Sons Inc. ISBN: 9780470665671, 9780470665671.