DEPARTMENT OF CHEMISTRY

SIDDHARTH UNIVERSITY KAPILVASTU, SIDDHARTH NAGAR

Title of the Course: M.Sc. Chemistry

SUK offers a Master of Science (M.Sc.) in Chemistry as a postgraduate degree programme. The goal of this programme is to provide in-depth information and skills to satisfy the current demands of business, educational, and research organizations. The redesigned curriculum is based on a choice-based credit system and is designed to keep up with the quality and amount of information in current chemical science. When developing these courses, effort was made to consider regional and national priorities while maintaining national and international educational standards. The credit-based system is a flexible curricular design with several advantages. It is free of many of the constraints connected with the traditional strict curricular paradigm. Each course is awarded a weight (credit) based on its relative relevance to the overall credit rating of the programme. In addition, many elective papers (options) have been offered to better prepare students for their future careers. The curriculum that will be adopted with this approach will allow students to transfer between schools due to personal obligations without wasting valuable time. This method also allows students to acquire a firm foundation in the fundamentals while having the freedom to choose courses of specialization in the field of his or her preference and ability. The term credit is used to represent the quantity of syllabus for various program in terms of hours of study. It denotes variable weightage assigned to courses in the Curriculum based on their contents and duration.

Rules and Regulations regarding postgraduate course starting from session2022-23

Post graduate course/program structure:

- There will be only one **Major Subject** in Post graduate program.
- Postgraduate program will run under C.B.C.S. and semester system.

- There will be four theory papers (each of 5 credit) or four theory and one experiment paper (each of 4 credit) of Major Subject in one semester. Thus there will be 20 credits of papers of Major Subject in one semester. There will be 40 credits in one year and 80 credits in two years.

Minor/open elective paper:

- Student will have to study a Minor elective paper in first year of post graduate program.
- Students may select the Minor/open elective paper available in even or odd semester by their convenience. Elective paper will be selected only from the papers of subjects running in the institute.
- Elective paper will be different from Major Subject. This paper will be of 4 credits.
- This paper will be for students of other faculty/department. Students of concerned Major Subject will not study it. They will have to study the minor elective paper of some other subject in place of it.
- In general, colleges will allot same time for classes of minor subject in time table sothat there is no clash of these classes with other subjects. The internal assessment of minor subject will also be held on same date and semester exam date will be decided by University.

Research project in postgraduate program:

- Student will have to do a detailed research project in 4th and 5th year (Ist and IInd yearof postgraduate program) of higher education.
- Student will have to do a research project related to Major subject elected by him inIVth and Vth year.
- This research project may be interdisciplinary or multidisciplinary. This research project may be in the form of Industrial training/ internship/ survey work etc.
- The research project will be done under the supervision of a faculty supervisor; another supervisor may be taken from any industry/ company/ technical institute/ research institute according to need of the subject.
- Graduate (including research) and postgraduate students will have to do a research project of 4 credits (4 hours per week) in each semester.
- Student will submit combined project report/dissertation of research project done in both semesters at the end of the year which will be evaluated jointly by an external
  Examiner appointed by university and supervisor in 100 marks at the end of the year. This way, there will be 8 credits for this exam.
- If a student publishes a research paper from his research project in a UGC care listed journal during postgraduate program, then he may be awarded up to 25 extra marksin evaluation of research project (from total of 100 marks). Max. Obtained marks will be 100 only.

Credit determination and attendance:

- To obtain postgraduate degree, it will be necessary to obtain minimum 52 credits inIst year and 48 credits in IInd year. The division of credits will be as follows:
  - 40 credits each year according to 20 credits each semester related to Majorsubject and total 80 credits.

- 4-4 credit for research project in each semester, so 8 credits in a year and total16 credits.
- 4 credit for minor paper in Ist year.

Thus, in total there are 80+16+4 = 100 credits.

- It will be necessary to give exam for credit validation. The credits will be incomplete without examination. The 75 percent attendance will be compulsory for giving examas before.
- If a student is eligible for giving exam on the basis of attendance, but unable to give exam due to any reason, then he may participate in the exam in the coming session. There is no need of taking classes again.
- The other rules concerned to credits will be according to rules and regulations issued earlier.

Minor elective paper:

- Every student will have to study a minor elective paper in I$_{st}$ year of postgraduate program.
- Students may study this paper in any even or odd semester. Therefore, it will be necessary to prepare one or two question papers in each subject.
- If two question papers are prepared, then it will be necessary to clearly mention in the course that both question papers are for different semesters of alternative to each other.
- Minor elective paper will be of 4 credits.
- The subject to which this minor elective paper belongs, the students of that subject will not study this minor paper. This paper will be available for choice for students of other subjects. The students of concerned subject will study minor paper belonging to other subject, not related to their Major subject. So this question paper should be prepared keeping in mind the case and usefulness for other subject students.

Research Project:

- Students will have to do a research project related to their Major subject in each subject.
- This project will be of 4 credit.
- It will be evaluated on the basis of project report prepared on the basis of work done in both semesters at the end of the year.
- This project report will be evaluated in 100 marks and it will be of total 8 credits (including both semesters).
- Hence, it will be necessary to do a research project of 4 credits per semester in the courses of all subjects.
- Above research project will be accomplished by student under the supervision of faculty of concerned subject in which a co-supervisor may be included according to the need of the subject.
- Student will submit the project report/dissertation of the research project done in both semesters at the

end of the year which will be evaluated by the external examiner appointed by the University and the supervisor jointly at the end of year in 100 marks. This way, there will be 8 credits for this exam.

- If a student publishes a research paper from his research project in a UGC care listed journal during postgraduate program, then he may be awarded up to 25 extramarks in evaluation of research project (from total of 100 marks). Max. obtained marks will be 100 only.
- The grades based on marks obtained in research project will be marked on mark sheet of student and these will be included in calculating CGPA.

Maximum marks:

- Every paper in each semester will be prepared for 100 marks excluding research project.
- Although there will be 4 credits per paper in research project but max. marks will not be 100 per semester. For this, max. 100 marks per year will be allotted which will be given to the student on the basis of evaluation of his project report and related viva- voce at the end of the year.

Evaluation:

- All the Major and minor subjects will be evaluated externally and internally both.
- Out of 100 max. marks, 25 marks will be awarded for internal evaluation and 75 marks for external evaluation.
- For internal evaluation, a written test of 10 marks will be conducted. 10 marks will be awarded for assignment and remaining 5 marks will be given on the basis of attendance and conduct of student in the class.
- For 75 marks, an external exam will be conducted by the University at the end of the semester for which rules and arrangement will be allocated separately.
- On the basis of research project done in both semesters, the prepared project report/dissertation will be evaluated by external and internal examiners in 50 marks separately. The student will be evaluated for 25 marks on the basis of concerned viva voce from his research project.
- Remaining 25 marks will be awarded to the student only when he will publish his research paper related to his research project in UGC care listed journal.

Table for post graduate Course Chemistry

SEMESTER - I				
Course code	**Credit/ maximum marks**	**Paper number**	**Paper name**	**Paper title**
MCHC-101	4/100	Paper-I	Symmetry	Molecular Symmetry and Molecular Vibrations
MCHC-102	4/100	Paper-II	Physical Chemistry	(Quantum Chemistry)
MCHC-103	4/100	Paper-III	Inorganic Chemistry	(Main Group Elements)
MCHC-104	4/100	Paper-IV	Organic Chemistry	Aromaticity and Reaction Mechanism
MCHL-105	4/100	Paper-V	Practical	Chemistry lab
MCHM-106	4/100	Paper-VI	Minor	Minor elective
MCHP-107	4/000	Paper-VII	Project/ Dissertation	Project/ Dissertation
	Total=28/600			

SEMESTER - II				
Course code	**Credit/ maximum marks**	**Paper number**	**Paper name**	**Paper title**
MCHC-201	4/100	Paper-I	Instrumental Chemistry	Analytical Chemistry
MCHC-202	4/100	Paper-II	Physical Chemistry	Thermodynamics and Electrochemistry
MCHC-203	4/100	Paper-III	Inorganic Chemistry	Transition elements
MCHC-204	4/100	Paper-IV	Organic Chemistry	Pericyclic reaction and Stereochemistry
MCHL-205	4/100	Paper-V	Practical	Chemistry lab
MCHP-206	4/100	Paper-VI	Project/Dissertation	Project/ Dissertation
	Total=24/600			

SEMESTER – III				
Course code	**Credit/ maximum marks**	**Paper number**	**Paper name**	**Paper title**
MCHC-301	4/100	Paper-I	Spectroscopy-1	
MCHC-302	4/100	Paper-II	Recent trends-1	Advances in chemistry
MCHE-303	4/100	Paper-III	Physical Chemistry	Elective paper
MCHE-304	4/100	Paper-IV	Physical Chemistry	Elective paper
MCHE-305	4/100	Paper-III	Inorganic Chemistry	Elective paper
MCHE-306	4/100	Paper-IV	Inorganic Chemistry	Elective paper
MCHE-307	4/100	Paper-III	Organic Chemistry	Elective paper
MCHE-308	4/100	Paper-IV	Organic Chemistry	Elective paper
MCHL-309	4/100	Paper-V	Physical Chemistry Practical	Chemistry lab
MCHL-310	4/100	Paper-V	Inorganic Chemistry Practical	Chemistry lab
MCHL-311	4/100	Paper-V	Organic Chemistry Practical	Chemistry lab
MCHP-312	4/000	Paper-VI	Project/ Dissertation	Project/Dissertation
	Total=24/500			

SEMESTER – IV				
Course code	**Credit/ maximum marks**	**Paper number**	**Paper name**	**Paper title**
MCHC-401	4/100	Paper-I	Spectroscopy-II	Advances in Chemistry
MCHC-402	4/100	Paper-II	Recent trends-II	Elective paper
MCHE-403	4/100	Paper-III	Physical Chemistry	Elective paper
MCHE-404	4/100	Paper-IV	Physical Chemistry	Elective paper
MCHE-405	4/100	Paper-III	Inorganic Chemistry	Elective paper
MCHE-406	4/100	Paper-IV	Inorganic Chemistry	Elective paper
MCHE-407	4/100	Paper-III	Organic Chemistry	Elective paper
MCHE-408	4/100	Paper-IV	Organic Chemistry	Elective paper
MCHL-409	4/100	Paper-V	Physical Chemistry Practical	Chemistry lab
MCHL-410	4/100	Paper-V	Inorganic Chemistry Practical	Chemistry lab
MCHL-411	4/100	Paper-V	Organic Chemistry Practical	Chemistry lab
MCHP-412	4/100	Paper-VI	Project/ Dissertation	Project/Dissertation
	Total=24/600			

Abbreviations:

MCHC : M.Sc. Chemistry Core paper

MCHM : M.Sc. Chemistry Minor elective

MCHE : M.Sc. Chemistry elective paper

MCHL : M.Sc. Chemistry Lab

MCHP : M.Sc. Chemistry Research Project

In course code:

Ist letter (M) : Master degree (M.Sc.)

IInd and IIIrd letter (CH) : Subject code (Chemistry)

IV letter (C,M,L,P,E) : Nature of course

(C: Core paper, M: Minor elective, L: Lab, P: Research Project, E: elective paper)

In Code Number:

101: First Number: Semester

Last number: paper number

Semester-I

Paper-I | **MCHC-101**

Molecular Symmetry and Molecular Vibrations

Objectives: The overall objective is to acquaint students with the fundamentals of symmetry and group theoretical methods and how to apply them to vibrational and electronic spectroscopy and to the study of molecular structure, bonding, and chemical reactivity.

Outcomes: Proficiency in using concepts of molecular symmetry to identify physical properties, Proficiency in applications of symmetry and group theory to various types of chemical systems; classification of molecules into symmetry point groups and use of character tables. Proficiency in constructing molecular orbitals and understand their role in determining molecular properties and reactivity, Understanding of principles and applications of spectroscopic techniques for determination of molecular structure, Basic understanding of solid state group theory.

Syllabus

1. **Molecular Symmetry:**
   a) Symmetry elements and symmetry operations with special reference to water, ammonia and ethane.
   b) Classification of molecules/ ions based on their symmetry properties.
   c) Derivation of matrices for rotation, reflection, rotation-reflection and inversion operations.
   d) Direct products.
   e) Symmetry point groups applied to all type of molecules (C_{nh}, D_{nh}, C_{nv}, T_d, O_h and I_h).
2. **Group in Molecular Symmetry:**
   a) Group multiplication basis, matrix representation, character of an operation, orthogonality, projection and shift operators, character tables, reducible and irreducible representations, groups subgroups, and classes.
   b) Symmetry of orbital: orbital symmetry properties, projection to get symmetry orbitals, projection operators, basis functions and hybrid orbitals with example.
3. **Molecular Vibrations:**
   a) Internal and symmetry coordinates, symmetry adapted linear combinations (SALCs), symmetry of normal vibrations, mixing of internal coordinates in normal modes, determination of symmetry types of the normal modes.
   b) Polyatomic molecular vibrations, IR and Raman active modes, analysis of vibration spectra of 1,2– dichloroethylene.
4. **Symmetry and Chemical reactivity**
   a) Symmetry considerations: electro cyclic and cycloaddition reactions.

Books Recommended:

1. DM Bishop, "Group theory and Chemistry" Dover Publications.

2. Cotton, "Chemical Applications of Group Theory", John Wiley.
3. M. Hamaresh, "Group theory and its Applications to Physical Problems" Addison- Wisley
4. R.L. Flurry, "Symmetry Groups"
5. Hanna "Quantum Mechanics in Chemistry".
6. McWeeny, "Symmetry - An Introduction to Group Theory", Pergamon Press.
7. Lowell H. Hall "Group Theory and Symmetry in Chemistry", McGraw Hill Book Company, New York.

Semester-I	
Paper II	**MCHC-102**
Physical Chemistry (Quantum Chemistry)	

Objective: Quantum Mechanics is a branch of science that deals with discrete, indivisible units of energy called quanta as described by the Quantum. It is an interfacial subject between Physics, chemistry and mathematics. Hence the objective of this course in chemistry is to understand clearly the microscopic and inner details of any reactions in chemistry view point.

Outcome: This is interfacial subject between Physics, chemistry and mathematics which provided a better scientific understanding and inner details of any physical or chemical reaction.

Syllabus

Unit-1 Fundamental concepts:

a. Quantum mechanical operators and classical variables
b. Linear operator in quantum mechanics
c. Vector Operators, Laplacian Operator and Hamiltonian Operator
d. Hermitian Operators, Concept of normalization and orthogonality in wave function
e. Postulates of quantum machines
f. Schrödinger equation
g. Eigen value problem in quantum mechanics
h. Wave function and probability
i. Particle in one and three-dimensional box and degeneracy of state.

Unit-2 Quantum mechanical treatments:

a. Quantum mechanical treatment of a harmonic oscillator, One dimensional Harmonic oscillator (Classical and quantum mechanical treatments), Energy levels of harmonic and an-harmonic oscillators
b. Quantum mechanical treatment of a rigid rotor

Unit-3 Quantum mechanical treatments of molecules:

a. Rigid rotor model of a diatomic molecule, Energy levels of a rigid rotor, rigid rotor, selection rule, A non-

rigid rotor.

b. Schrodinger equation for H atom: Transformation of coordinates, Separation of Variables, φ, Θ and R equations and their solutions, Spherical harmonics, electron spin.

Unit-4 Approximation methods:

The variation method, Perturbation method, first order perturbation theory

Books recommended:

1. Modern quantum chemistry: An introduction to Advance Electronic Structure Theory by a Szabo and NS Ostland
2. Quantum Chemistry by Donald A. Mcquarrie
3. Molecular Quantum Mechanics by P.W. Atkins and R.S. Friedman

Semester-I	
Paper III	**MCHC-103**

INORGANIC CHEMISTRY (Main Group Elements)

Objective: Objective of first part (Main group Chemistry) is to provide basic concepts on synthesis, structure, bonding and properties of some selected main group elements. Second part (Transition metal Chemistry) will be useful in building a conceptual framework for understanding the principles and theories that account for the physicochemical properties of coordination compounds.

Outcome: Students will gain the fundamental knowledge about the synthesis, structure, bonding and properties of some selected main group elements. Exposure to the fundamental concepts on different theories of bonding and their relation to the properties of transition metal coordination compounds will be helpful in understanding the role of this class of compounds in different fields of application like in Organometallic Chemistry or Bioinorganic Chemistry for future study.

Syllabus

1. Preparation, Structure, Bonding and Technical Applications of

(a) Polyether complexes of alkali and alkaline earth metals

(b) Polyphasphazenes

(c) Thiazyl and its polymers, tetrasulfurdinitride.

2. Structure and bonding of Borane & Carborane
3. Structure of Silicon and Silicates
4. Preparation, Properties, Structure and Applications of Alkyl and aryls of Lithium, Beryllium, Magnesium, Aluminum, Mercury and Tin.

Books Recommended:

1. Advance Inorganic Chemistry, 6th Edition, Cotton and Wilkinson
2. Inorganic Chemistry, 4th Edition, Principles of Structure and Reactivity by J.F. Huheey, E.A. Keiter and R.L. Keiter, 1993
3. Chemistry of Elements by N.N. Greenwood and A. Ernshaw, Butterworths 1997
4. Organometallic Chemistry: A Unified Approach by R.C. Mehrotra and A.K. Singh
5. Comprehensive Coordination Chemistry Vol.3 by G. Wilkinson, R.D. Gillard, And J.A. McCleverty, Pergamon Press 1987.

Semester-I

Paper IV	**MCHC-104**

ORGANIC CHEMISTRY (Reaction Mechanism)

Objective: Primary aim of this course is to develop interest and skill for generating mechanistic path for organic transformations in the students. The focus of this course is to give the detailed insight of organic reaction mechanism and to understand the physical chemistry of organic reactions along with the nucleophilic substitution reaction, elimination reaction & addition on Carbon-Carbon double bond.

Outcome: After completion of the course, students will understand the mechanistic pathways of the various organic reactions. Students will become competent to predict the chemo-, regio- and stereoselective outcome of such reactions.

Syllabus

UNIT 1: Basic Principles of organic reaction mechanism: potential energy diagram, transition states and intermediates, methods of determination of organic reaction mechanism, Kinetic isotopic effect and its importance in the determination of reaction mechanism.

UNIT 2: Substitution Reaction: Aliphatic Nucleophilic Substitution at Saturated Carbon Atom: Mechanism and stereochemistry of SN^1, SN^2, and SN^i reactions. Role of structure of substrate, nucleophile, leaving group and solvent on SN reactions, Nucleophilic substitution in bridged systems, Neighbouring Group Participation: Evidence for NGP, Participation by π and σ bonds.

UNIT 3: Elimination Reaction: E1, E2 and E1Cb mechanism, Orientation (Saytzeff and Hofmann Rule), Stereochemistry of E2 elimination, E1, E2 and E1Cb spectrum, factors affecting E1, E2 and E1Cb reactions, Competition between substitution and elimination.

UNIT 4: Addition on Carbon-Carbon double bond: Mechanism and stereochemistry of addition of halogen acids to alkenes, 1,2-Bishydroxylation, Epoxidation, Hydroboration and Oxymercuration-demercuration, Sharpless asymmetric epoxidation. Addition to Carbon-hetero multiple bond: Mechanism of addition to C=O bonds,

condensation reaction involving enolate e.g., Aldol condensation, Claisen condensation, Perkin reaction and Knoevenagel reaction.

Books Recommended:

1. Advance Organic Chemistry – Structure and Mechanism, J. March, John Wiley
2. Advanced Organic Chemistry_FACarey and RJSundberg_A
3. Advanced Organic Chemistry_FACarey and RJSundberg_B
4. Modern Methods of Organic Synthesis-W. CARRUTHERS & I. COLDHAM-
5. Modern Organic Synthesis-Zweifel & Nantz

Semester-I

Paper -V | **MCHL- 105**

CHEMISTRY PRACTICAL

Objective: To enable students to carry out, and interpret measurements within the context of the fundamental technological problem with which they are presented.

The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for qualitative and quantitative analysis, preparation, separation techniques, isolation, extraction and characterizations using chemical and spectral and other modern techniques. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes.

Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.

Syllabus

Physical practical exercises:

1. Determine the distribution coefficient of benzoic acid between benzene and water.
2. Determine the distribution coefficient of acetic acid between benzene and water.
3. Study the adsorption of acetic acid on charcoal and draw the Freundlich isotherm.
4. Show that the order of reaction between acetone and iodine is zero with respect to iodine.

Inorganic exercises

1. Qualitative analysis of an inorganic mixture of seven radicals including Tl, W, Se, Te, V, Be, U, Ti, Zr, Th, Ce and Li, in addition to the radicals prescribed for the B.Sc. Course. Semi micro analysis is to be done.
2. Chromatographic separation of metal ions given in any one of the following combinations:
   - **(a)** Pb^{2+}, Ag^{+}, Hg_2^{2+}
   - **(b)** Co^{2+}, Ni^{2+}, Cu^{2+}
   - **(c)** Fe^{3+}, Cr^{3-}, Al^{3-}
   - **(d)** Ba^{2+}, Sr^{2+}, Ca^{2+}

Organic exercises:

1. Analysis of primary binary organic mixture (liquid-liquid, liquid-solid, solid-solid)
2. Determination of equivalent weight of organic acids by direct titration method

Recomonded books

1. Advanced Physical Chemistry by J.B. Yadav
2. Chemistry Practical by Bajpai and Giri

Semester-I

PAPER- VI **MCHM- 106**

CHEMISTRY IN EVERYDAY LIFE (MINOR ELECTIVE)

Objectives: This course aims to impart to the student, knowledge of Environmental chemistry, Green Chemistry, Daily life chemistry, and Polymers.

Outcomes: On completion of the course, students should be able to understand Atmospheric Chemistry and Air Pollution, roll and importance of Vitamin, Toxic Organic Compounds, catalysts, Chemical energy storage and conversion, Water Pollution and Basic concepts of polymers.

Syllabus

Unit:1 Environmental chemistry:

(1) Atmospheric Chemistry and Air Pollution;

(2) Climate Change and Energy;

(3) Water Chemistry and Water Pollution; and

(4) Toxic Organic Compounds.

Unit: 2 Green Chemistry:

12 Principle of green chemistry, choice of feedstock, solvents, catalysts, synthesis routes including microwave and ultrasonic assisted synthesis, Chemical energy storage and conversion, Carbon dioxide utilization

Unit: 3 Daily life chemistry:

Medicinal role and importance of Vitamin A, B, C, D, E and K, Protein and carbohydrate metabolism.

Unit: 4 Polymers

Basic concepts of polymers, Natural and synthetic polymers- Organic and inorganic polymers, Thermoplastics and Thermosetting Plastics, elastomers, fibers and liquid resins. Addition polymers and condensation polymers-Homo-polymers and copolymers- linear, branched and cross linked polymers.

Recommended book

1. Environmental Chemistry" by Anil Kumar De. ...
2. Environmental Chemistry" by B K Sharma
3. Green Chemistry: Environmentally Benign Reactions" by V K Ahluwalia.
4. New Trends in Green Chemistry" by V K Ahluwalia and M Kidwai
5. Lehninger's Principles of Biochemistry.

6. Principles and Techniques of Biochemistry and Molecular Biology.
7. Fundamentals Of Polymer Science & Technology by Anshu Srivastava & Shakun Srivastava, S.K. Kataria & Sons

Semester-I	
Paper VII	**MCHP- 107**
Chemistry Project/Dissertation	
Project/Dissertation This course will provide you with guidance and support throughout the writing of your dissertation. From discussing your initial ideas of your dissertation through the process of actually writing the document, this course will provide you with the information and support required from both the teaching staff and your allocated dissertation supervisor.	

Semester-II	
Paper I	**MCHC-201**
Analytical chemistry	
Objective: To provide basic understanding of the principles, instrumentation and application of chemical analysis techniques. **Outcome:** On completion of the course, students acquire knowledge to select proper techniques and instrumentation for particular sample analysis.	
Syllabus **1. Electroanalytical Techniques:** (a) **Conductometric:** Discussion of the nature of the curves of acid-base (including mixtures of acids), precipitation and complexometric titrations. (b) **Potentiometric:** different types of electrodes, discussion of nature of the curves for oxidation-reduction and acid-base titrations, comparison with the conductometric method. (c) **Voltammetry,** Cyclic voltammetry (d) **Polarography:** Dropping mercury electrons and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half-wave potential, Ilkovic equation and factors affecting diffusion current. **2. Thermo-analytical Methods:** (a) Thermo-gravimetry: apparatus, factors affecting TGA, interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$ (b) Differential Thermal Analysis: Apparatus, factors affecting DTA curves with Special reference to heating rate, Particle size and packing, measurement of heat of transition, heat of reaction and heat	

of dehydration of salts of metal hydrates.

3. **Radiochemical methods:**
   (a) Isotope Method
   (b) Neutron activation technique.
4. **Chromatographic Method:**
   (a) Gas Chromatography: GLC and GC
   (b) HPLC

Books Recommended:

1. Fundamentals of analytical chemistry, D.A. Skoog, D.M. West and F.J. Holler
2. Quantitative inorganic analysis, A.I. Vogel
3. Instrumental Methods of Chemical Analysis, B.K. Sharma
4. Instrumental Methods of Chemical Analysis, H. Kaur
5. Analytical Chemistry, Gary D. Christian

SEMESTER-II	
Paper II	**MCHC-202**

PHYSICAL CHEMISTRY (Thermodynamics and Electrochemistry)

Objective: Chemical kinetics is concerned with the study of the dynamics of chemical reactions. The raw data of chemical kinetics are the measurement of rates of reaction; the desired final product is the explanation of these rates in terms of complete reaction mechanisms. The objective of the present course is to introduce the foundation of the subject by studying series of reactions of increasing complexity and to show how experimentally measured parameters may be used to propose new models (mechanism) or verify existing models.

Outcome: This course will enable student calculate the rate of reaction, desired final product, and yield of reaction and to understand the possible reaction mechanism.

Syllabus

Unit-1 Some important thermodynamic effects and relationships: Joule Thomson's effect, temperature dependence of free energy; Gibbs Helmholtz equation and its application, The Clausius Clapeyron equation. Thermodynamics relations; The Maxwell's relation, Thermodynamic equation of state, Relationship between E or H and P, V, T, partial molar quantities; partial molar volume and partial molar Gibbs energy, Experimental determination of excess molar volume,

Unit-2 Chemical potential and Third Law of Thermodynamics: Chemical potential and its variation with T and P, applications of Chemical Potential, Gibbs Duhem equation, fugacity and activity coefficient and its determination. The third law of thermodynamics, The Nernst heat theorem and entropy calculations, the residual entropy.

Unit-3 Electrochemistry: Brief description of ion- association, Wein effect and Debye – Falkenhagen effect, Effect of ionic strength on the rate of ionic reactions. The Electrical double layer, electro kinetic phenomena,

Unit-4 Electrode Processes: Concentration polarization, deposition and decomposition potentials, Overvoltage, Limiting current density and Dropping Mercury Electrode.

Recommended books

1. Electrochemistry by Samuel Glaston
2. Thermodynamics by RP Rastogi
3. Thermodynamics by K.L. Kapoor
4. Physical Chemistry by Atkins

SEMESTER-II

Paper III | **MCHC-203**

INORGANIC CHEMISTRY (Transition Elements)

Objective: First part (Organometallics) is designed to provide the basic knowledge of coordinate metal complexes chemistry with reference to synthesis, structures, bonding, reactivity and application of o compounds. Second part deals with role of kinetics and mechanism, stereoisomerism and Metal Ligand Equilibria in Solution.

Outcome: Students will learn the basic features of coordinate metal complexes chemistry, kinetics and mechanism, stereoisomerism and Metal Ligand Equilibria in Solution, which are very important for different application.

Syllabus

1. Structures of 2 to 8 Coordinate Metal Complexes

   Cation-anion ratio in various polyhedral, Hybrid orbitals and preferred conditions of formation of the complexes of following geometries:

   C.N.2 -Linear

   C.N.3 - Trigonal planar, Trigonalpyramidal

   C.N.4 - Tetrahedral, Squareplanar

   C.N.5 - Trigonal bipyramidal, Square pyramidal,pentagonal.

   C.N.6 - Octahedral, Trigonalprism

   C.N.7 - Pentagonal bipyramidal, Capped octahedral, Capped trigonalprism.

   C.N.8 - Cubic, Tetragonal antiprismatic, Dodecahedral, Hexagonal bipyramidal, and Bicapped trigonal prism, Stereochemical non-rigidity in four to eight coordinate Complexes.

2. **Kinetics and mechanism** of substitution reactions in octahedral Co (III) and square planar Pt (II) complexes.
3. Stereoisomerisms in six coordinate octahedral complexes (Ma_3bcd, Ma_2bcde, Mabcdef and complexes containing bi- and ter -dentate ligands, intermolecular and intramolecular rearrangements (Bailar and Ray dutta Twist) Mechanism of racemization in tris (chelate) octahedral complexes, methods of resolution of optical isomers.

4. Metal Ligand Equilibria in Solution:

Step wise and overall formation constants and their relations, Factors affecting the stability of metal complexes with reference to the nature of metal ions and ligands, determination of stability constants by pH-metric and spectroscopic methods.

Recommended Books:

1. Inorganic Chemistry, 4th Edition, Principles of Structure and Relativity by J.E. Huheey, E.A. Keiter and R.L. Keiter, 1993
2. Chemistry of Elements by N.N. Greenwood and A. Ernshaw, Butterworths, 1997
3. Mechanism of Inorganic Reactions; A Study Of Metal Complexes in Solution by F. Bosolo and R.G. Pearson
4. Ligand Field Theory and Its Application by B.N. Figgis and M.A. Hitchman, Wiley, NewYork, 2000.

SEMESTER-II

PAPER IV **MCHC-204**

ORGANIC CHEMISTRY (Stereochemistry and Pericyclic chemistry)

Objective: This course is framed to provide in- depth understanding of some important aspects of Stereochemistry, Pericyclic reactions, Stereochemistry and reactivity of cyclohexane and asymmetric synthesis.

Outcome: On the completion of the course students will have the understanding of basics of organic Photochemistry and Pericyclic reactions. Various theories/rules governing these pericyclic reactions will help them to predict the products with stereochemistry involved in these reactions.

Syllabus

Unit 1: Stereochemistry: Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, Interconversions of Fischer, Newman's and Saw-Horse projections, configurational projections, R/S nomenclature, Principle of chirality, optical isomerism of biphenyl, alkenes and spiranes, optical activity due to intramolecular overcrowding, absolute configuration, Introduction, Homotopic, enantiotopic and diastereotopic atoms.

Unit 2: Asymmetric synthesis: Regioselectivity, stereo selectivity (enantioselectivity and diastereoselectivity) and Stereo specificity, Asymmetric synthesis involving chiral reagent and chiral catalysis.

Unit 3: Stereochemistry and reactivity of cyclohexane: Configuration, conformation and stability of mono and di-substituted cyclohexane and cyclohexanones, Reactivity of substituted cyclohexane.

Unit 4: Pericyclic reactions: Introduction, classification and characteristics, Conservation of Molecular orbital symmetry, Use of correlation diagrams: FMO and PMO approach to study Electrocyclic reactions of linear conjugated diene, triene and allyl systems., Cycloaddition reactions involving [2+2] and [4+2] systems., Sigmatropic rearrangements ([1,3], [1,5] and [3,3])., Claisen, cope -rearrangements,

Recommended Books

1. Pericyclic Reaction and Organic Photochemistry BY Dr. Vinay Prabha Sharma, Rakesh Kumar

2. Organic Synthesis BY Dr.Jagdamba Singh, Dr. L.O.S. Yadav
3. Stereochemistry By P. S. Kalsi
4. Stereochemistry By D. Nasipuri

SEMESTER-II

Paper-V **MCHL-205**

Chemistry Practical

Objective: To empower students to carry out, and interpret measurements within the context of the fundamental technological problem with which they are presented. The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for qualitative and quantitative analysis, preparation, separation techniques, isolation, extraction and characterizations using chemical and spectral and other modern techniques. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes.

Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.

Syllabus

Physical practical exercises:

1. Draw the solubility curve for water-acetic acid- chloroform system.
2. Study the adsorption of oxalic acid on charcoal and draw the Freundlich isotherm.
3. Determine the rate constant of the acid-catalyzed hydrolysis of ethyl acetate at laboratory temperature.
4. Determine the rate of constant of the hydrolysis of ethyl acetate by sodium hydroxide at laboratory temperature.
5. Carry out the conductometric titration between the strong acid and strong alkali.
6. Determine the dimerization constant of benzoic acid in benzene medium by partition method.
7. Determine the solubility of salicylic acid in water at different temperatures and calculate the heat of solution.

Inorganic

Either both gravimetric and one volumetric estimation of two metal ions from following mixtures:

(a) Cu^{2+} and Ni^{2+}

(b) Cu^{2+} and Zn^{2+}

(c) Ni^{2+} and Zn^{2+}

(d) Cu^{2+} and Ba^{2+}

(e) Cu^{2+} and Ag^{+}

(f) Ba^{2+} and Ag^{+}

Organic Chemistry

Preparation of organic compounds involving two stages, Emphasis should be given in the following Processes: Purification, distillation under reduced pressure, steam distillation, and fractional crystallization

Recommended books

1. Advanced Physical Chemistry Experiments by Dr.J.N. Gurtu, A.Gurtu
2. Advanced Practical Organic Chemistry by O.P. Agarwal

SEMESTER-II	
Paper-VI	**MCHP-206**

Project/Dissertation

This course will provide you with guidance and support throughout the writing of your dissertation. From discussing your initial ideas of your dissertation through the process of actually writing the document, this course will provide you with the information and support required from both the teaching staff and your allocated dissertation supervisor.

SEMESTER-III	
PAPER-I	**MCHC-301**

Spectroscopy- 1

Objective: The objective of the course is to help students understand the theoretical aspects of various spectroscopic techniques like UV-Visible, IR, NMR and Mass, which in turn, will enhance their capability of interpreting the spectral data obtained from various techniques and use it for structural elucidation of organic compounds.

Outcome: Students acquire the knowledge of the instrumentation and principle involved in various advanced spectroscopic and will be able to interpret the spectral data for structural elucidation of organic compounds.

Syllabus

1. **UV-Visible Spectroscopy**

   Different type of electronic transitions, Lambert's Beer's law, Chromophores, Auxochromes, Solvent effect, Red shift and blue shift, Woodward's rule for conjugated cyclic and acyclic dienes and α, β – unsaturated carbonyl compounds, Absorption in aromatic compounds (substituted benzene, naphthalene and anthracene), Problems related UV-Visible Spectroscopy

2. Infrared Spectroscopy

Review of linear harmonic oscillator, Vibrational energies of diatomic molecules, Zero point energy, Force constant and bond strength, Anharmonicity, Morse potential energy diagram, Vibration rotation spectroscopy, P, Q, R branches, Breakdown of Born-Oppenheimer approximation, Selection rules, Overtones, Hot Bands, Absorption by common functional groups, Brief description of IR and F.T.I.R. instruments, Problems related I.R. Spectroscopy

3. Raman Spectroscopy

Theories of Raman Effect, Conditions of Raman active Vibrations, Selection rules, Polarized and Depolarized Raman lines Study of: (Simple molecules such as SO_2, CO_2, N_2O and C_2H_2; (b) Hydrogen Bounding and (c) Metal ions in solution, Mutual exclusion principle, Problems related with Raman Spectra and its interpretation

4. Microwave spectroscopy

Rotational Spectroscopy, Rotational spectra of diatomic molecules based on rigid rotator approximation, Determination of bond lengths and/or atomic masses from microwave data, Effect of isotopic substitution, Non-rigid rotator, Classification of polyatomic molecules, Energy levels and spectra of symmetric top molecules and asymmetric top molecules and applications.

Recommended Books

1. Spectroscopy by H. Kaur
2. Molecular Spectroscopy by Benwell
3. Spectroscopy by B.K. Sharma
4. Spectroscopy of organic Compounds by P.S. Kalsi
5. Vibrational Spectroscopy theory and applications by D.N. Santhyanarayana

SEMESTER-III	
Paper-II	**MCHC-302**

Recent trends in Chemistry-I

Objective: To understand the development and new approaches for designing of safer chemical process & product without causing harm to the environment and human life. To foundational knowledge of the Nanoscience, Green Chemistry, Supramolecular Chemistry, drug design. To make the students acquire an understanding the Nanoscience, Green Chemistry, Supramolecular Chemistry, drug design and Applications

Outcome: Students will acquire the fundamental knowledge about the innovative approaches for designing of safer chemical products, processes and use of renewable resources for sustainable development. Students will learn about the background of Nanoscience, Green Chemistry, Supramolecular Chemistry, drug design and Applications.

Syllabus

1. **Nanoscience:** Introduction of nanotechnology, Nanostructures: Carbon Nanotubes (CNT), Graphene's, Fullerenes, metallic nanoparticle, Nano Peapods, Quantum Dots and Semiconductor Polymer-based

dendrimers, sphere and fiber, Nanomaterial for energy storage application.

2. **Green Chemistry:** introduction & importance of green chemistry, Limitations in the pursuit of the goals of Green Chemistry, twelve principles of Green Chemistry, Prevention of Waste/ byproducts, Atom Economy, use of microwaves and ultrasonic assisted reaction, bio catalysis and photocatalysis.
3. **Supramolecular Chemistry**
   Definition, classification of supramolecular host-guest compounds, nature of supramolecular interactions, Chelate and macrocyclic effects. General principles of molecular recognition & complex formation and host design, templates and self-assembly. **Host-Guest Chemistry**
   (i) Cation Binding hosts
   (ii) Crown ethers
   (iii) Cryptands, Spherands
4. **Drug Design:**
   Development of new drugs, Introduction to drug design, solubility & permeability, drug likeness, pharmacophore, Lipophilicity, Structure activity relationship (SAR), Factors affecting bioactivity, isosterism, bio-isosterism, spatial considerations, Theory of drug activity.

Recommended books

1. Introduction to Nanoscience and Nanotechnology by Chattopadhyay K.K
2. An Introductory Text on Green Chemistry: For Undergraduate Students Indu Tucker Sidhwani & Rakesh K. Sharma
3. an introduction to green chemistry by V. Kumar
4. Supramolecular Chemistry - Fundamentals and Applications: Advanced Textbook by Katsuhiko Ariga & Toyoki Kunitake
5. Advances in Supramolecular Chemistry G. W. Gokel
6. Drug Delivery: Materials Design and Clinical Perspective by Eric P. Holowka & Sujata K. Bhatia

SEMESTER-III

SPECIALIZATION: PHYSICAL CHEMISTRY

PAPER III **MCHE-303**

Quantum Chemistry and their application

Objective: To understand Huckel Molecular Orbital Theory and its Applications, Semi–Empirical and Ab–Initio SCF Theories, DFT, Thermodynamics of Irreversible Processes.

Outcome: Students will acquire the fundamental knowledge about the Advanced quantum mechanics. Students will learn about the background of Huckel Molecular Orbital Theory and its Applications, Semi–Empirical and Ab–Initio SCF Theories, DFT, Thermodynamics of Irreversible Processes.

Syllabus

Unit-1 Huckel Molecular Orbital Theory and its Applications:

Calculation of energy levels and delocalization energy of butadiene, cyclic conjugated polyolefin - cyclopropenyl, cyclobutadiene, cyclopentadienyl, benzene, tropylium radical and cyclooctatetraene.

Unit-2 Semi–Empirical and Ab–Initio SCF Theories:

Hartee-Fock Self consistent field (SCF) method, Semi–empirical SCF theory (CNDO, INDO & MNDO), Slater

and Gaussian type orbitals, configuration interaction and electron correlation, Moeller- Plasset Perturbation methods.

Unit-3 Introduction to density functional theory:

Concept of basic sets, exchange-correlation energy and Kohn-Sham orbitals, Local Density Approximation (LDA) and Generalized Gradient Approximation (GGA), Significance of Density Functional Theory.

Unit-4 Thermodynamics of Irreversible Processes:

Entropy production in irreversible processes, Entropy equation for heat flow, relation between fluxes and forces, Non-equilibrium stationary states, linear phenomenological equations, Onsager's reciprocity relation, non-linear thermo-osmosis and reverse osmosis, Intermolecular Forces: Dispersion, dipole, induction and Charge transfer forces. The hydrogen bond.

Books Recommended:

1. Chemical Application of Group Theory – F.A. Cotton
2. Introductory Quantum Chemistry – A.K. Chandra
3. An Introduction to Quantum Mechanics of Chemical Systems – R.P. Rastogi and V.K. Srivastava
4. Physical Chemistry – P.W. Atkins
5. Valence Theory – J.N. Murrell, S.F.A. Kettle and J.M. Teddor
6. Chemistry by Ira N. Levine Prentice Hall of India New Delhi 1995.
7. Coulson's volume by R. McWeeny ELBS 1978.

SEMESTER-III	
SPECIALIZATION: PHYSICAL CHEMISTRY	
PAPER IV	**MCHE-304**

Electrokinetics Chemistry

Objective: To understand Conductance in non–aqueous media, Electro Kinetic Phenomena, Electrodics and Corrosion.

Outcome: Students will acquire the fundamental knowledge about the Conductance in non–aqueous media, Electro Kinetic Phenomena, Electrodics and Corrosion and prevention of corrosion.

Syllabus

Unit-1 Conductance in non–aqueous media:

Ion association, its effect on conductance, diffusion of electrolytes, measurements of coefficient, diffusion in relation to conductance.

Unit-2 Electro Kinetic Phenomena:

Quantitative treatment of electro–osmosis, electrophoresis and streaming potential, electrical layer theories

Unit-3 Electrodics:

The equilibrium exchange current density, Butler–Volmer Equation Tafel plot, high field and low field

approximation

Unit-4 Corrosion:

The mechanism of corrosion of metals, corrosion current and corrosion potential, electro-chemical corrosion theory, estimation of corrosion rates, corrosion prevention, polarization resistance, electro- deposition.

Books Recommended:

1. S. Glasston : Electro Chemistry
2. Robinson & Stokes : Electrolytic Solutions
3. Potter : Electro chemistry
4. Bockris and Reddy: Modern Electrochemistry Vol I and II
5. Mc Donald : Electro Chemical impedence spectroscopy

SEMESTER-III

SPECIALIZATION: INORGANIC CHEMISTRY

Paper III **MCHE-305**

Coordination Chemistry

Objective: To understand Energy levels in an atom, Electronic spectra of complexes, Magnetic properties of Complexes, Metal-ligand bonding.

Outcome: Students will acquire the fundamental knowledge about the understand Energy levels in an atom, Electronic spectra of complexes, Magnetic properties of Complexes, Metal-ligand Bonding.

Syllabus

1. **Energy levels in an atom:**
   Relation between electronic configuration and energy terms, Hund's rules and ground state energy terms, Inter electron repulsion parameter, Variation of Racah B and C parameters in different transition series. Spin orbit coupling parameters.
2. **Electronic spectra of complexes:**
   Orgel diagrams, mixing of terms, transition from weak to strong field and correlation diagram for only d^2 case, Non-crossing rule, Tanabe Sugano diagrams. Interpretation of the spectra of aqueous solution of $M[H_2O]^{n+}$, calculation of Dq, B and β parameters, Jahn Teller distortion and its effect on electronic spectra,
3. **Magnetic properties of Complexes:**
   Dia, para, ferro and antiferromagnetism, Quenching of orbital angular momentum by ligand. The magnetic properties of A, E and T terms.
4. **Metal-ligand Bonding**
   Limitations of CFT, Nephelauxetic series, molecular orbital energy level diagram of octahedral, tetrahedral and square planner complexes.

Books recommended:

1. B.N. Figgis, M.A. Hitchman, Ligand Field Theory and Its Applications, Willey, New York, 2000
2. D. Sutton, Electronics Spectra of Transition Metal Complexes.
3. K. Veera Reddy, Symmetry and Spectroscopy of Molecules.

SEMESTER-III

SPECIALIZATION: INORGANIC CHEMISTRY

Paper IV **MCHE-306**

Chemical Application of Symmetry and Group Theory

Objectives: The overall objective is to acquaint students with the fundamentals of symmetry and group theoretical methods and to the study of Matrices Representation, Normal Modes of Vibrations.

Outcomes: Proficiency in using concepts of molecular symmetry to identify physical properties, Proficiency in applications of symmetry and group theory to various types of chemical systems; classification of molecules into symmetry point groups and use of character tables. Proficiency in constructing molecular orbitals and understand their role in determining molecular properties and reactivity,

Syllabus

1. **Symmetry and Point Groups:**
   Definitions, the symmetry point groups, identification of molar point groups, molecules of low symmetry, high symmetry and special symmetry (C_n, S_n, D_n, C_{nv}, and D_{nh} only)
2. **Groups, Sub-Groups and Classes:**
   Definitions, multiplication tables, group generating elements, sub-groups and classes, irreducible representations, the orthogonality Theorem.
3. **Matrices Representation:**
   Matrix Representations of symmetry elements, block-factorization of larger matrices, matrix representation of C_{3v}, and C_{4v}, point groups, transformation matrices.
4. **Normal Modes of Vibrations**

Recommended Books:

1. Chemical applications of group theory. F. A. Cotton. 2nd Ed. Wiley Eastern. 1971.
2. Group theory and symmetry in chemistry. L. H. Hall. McGraw Hill Inc. 1969.
3. Symmetry, Orbitals and Spectra. M. Orchin and H. H. Jaffe. Wiley interscience. 1971.
4. Molecular Orbital Theory. C.J. Ballhausen and H. B. Gray. W. A. Benzamin Inc. 1965

SEMESTER-III

SPECIALIZATION: ORGANIC CHEMISTRY	
Paper III	**MCHE-307**
Natural Products	
Objectives: The overall objective is to acquaint students with the fundamentals of natural products, Alkaloids, Terpenoids, Vitamins & hormones. **Outcomes:** Upon completion of this course, the student shall be able to: Get insights into plant derived therapeutic leads, Biogenesis of Natural Products, Terpenoids, and Alkaloids. Optimize the extraction technique according their chemical class. Perform a bioassay guided isolation to improve throughput for identification of potential bioactive natural products. Contribute towards the development of herbal formulations for the prophylactic use.	
SYLLABUS **UNIT 1: Biogenesis of Natural Products:** The isoprene rule, malonic acid from acetyl coenzyme A, Biogenesis of terpenoids and alkaloids. **UNIT 2: Alkaloids:** Structure elucidation of alkaloids – a general account, structure, and synthesis of – Nicotine, Morphine, and Coniine. **UNIT 3: Terpenoids:** Importance of terpenoids, General structure determination of terpenoids, Structural elucidation and synthesis of terpenoid, camphor and abietic acid. **UNIT 4: Vitamins & hormones:** **Chemistry and physiological function of following:** Riboflavin, Calciferol, Tocoferol, vitamin C, hormones-Estrogen, androgen, Adrenalines.	
Recommended Books: 1. Organic Chemistry, Vol 2, I.L. Finar, ELBS 2. Natural Products by O P Agarwal	

SEMESTER-III	
SPECIALIZATION: ORGANIC CHEMISTRY	
Paper IV	**MCHE-308**
Aromaticity, Rearrangements & Reagents	
Objectives: To obtain foundational knowledge of the Aromaticity, Electrophilic and Nucleophilic Substitution, Rearrangements, Reagents. **Outcome:** After completing this course student will be able to: Understand the aromaticity and aromatic compounds, aromatic Electrophilic and Nucleophilic Substitution, Rearrangements, Reagents	

Syllabus

1. **Aromaticity:** Concept of aromaticity, antiaromaticity, nonaromaticity and homoaromaticity, Alternant and nonalternant systems, Aromaticity in nonbenzenoids (tropolone, azulene, annulenes, and fullerene).
2. **Aromatic Electrophilic and Nucleophilic Substitution:**
   Aromatic Electrophilic Substitution: General view, energy profile diagram, Arenium ion mechanism (ArSE), ortho/ para ratio and ipso substitution.
   Aromatic Nucleophilic Substitution: aromatic SN^1 and SN^2 reaction (ArSN). Addition –Elimination (ipso) and elimination- addition (benzyne) mechanisms, Effect of substrates, structure, nucleophile and leaving group.
3. **Rearrangements**: Mechanism and application of Favorskii, Curtius and Schmidt Rearrangement, Demjanov rearrangement, Lossen rearrangement, Wolff Rearrangement, Sommelet–Hauser rearrangement, Wittig Rearrangement.
4. **Reagents**: Preparation and application in organic synthesis of following:

a) DCC, DDQ, CH_2N_2, LDA, R_2CuLi, and 1,3-dithane
b) Wilkinson's catalyst and Phase-transfer catalyst.
c) Sulphur, and phosphorous ylides, enamines.

Books recommended:

3. Reaction Mechanism in Organic Chemistry -A.M. Mukherjee, S.P. Singh
4. Organic Chemistry Reaction and Reagents - O.P. Agarwal
5. Molecular Orbital Methods in Organic Chemistry (HMO) and PMO- William B. Smith
6. Name reactions and reagents in organic synthesis by Mundy, Ellerd & Favaloro-

Semester-III

SPECIALIZATION: PHYSICAL CHEMISTRY

Paper V **MCHP-309**

PHYSICAL CHEMISTRY PRACTICAL

Objective: To empower students to carry out, and interpret measurements within the context of the fundamental technological problem with which they are presented. The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for qualitative and quantitative analysis and characterizations using chemical and spectral and other modern techniques. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes. Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D

activities.

Syllabus

1. pH-Metry :

   Determination of strength or concentration of strong acid and strong base, Determination of strength of weak acid by pH titration with a strong base, Verification of Henderson's equation.

2. Conductometry:

   Equivalent conductance of strong electrolytes at infinite dilution, Conductometric titration of strong acid with strong base Conductometric titration of weak acid with strong base Titration of mixtures of acids Precipitation titration, Verification of Ostwald's dilution law Verification of Kohlrausch's Law

3. Potentiometry

Recommended books:

1. Advanced Physical chemistry by J.B. Yadav

Semester-III

SPECIALIZATION: INORGANIC CHEMISTRY

Paper V **MCHP-310**

INORGANIC CHEMISTRY PRACTICAL

Objective: To empower students to carry out, and interpret measurements within the context of the fundamental technological problem with which they are presented. The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for qualitative and quantitative analysis and characterizations using chemical and spectral and other modern techniques. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes. Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.

Syllabus Practical

1. Gravimetry estimation of three metal ions from following: Ag^{+}, Cu^{++}, Ni^{++}, Zn^{++}, Fe^{+++}, Al^{+++}, Ba^{++} and Mg^{++}
2. EDTA Titration:

Estimation of Mg^{++}, Zn^{--}, and Mg^{++} and Ca^{++} in admixture.

Preparation and Characterization of some metal complexes.

Recommended books:

Textbook of Textbook of Quantitative chemical analysis (6th Edition) chemical analysis (6th Edition) .J. Mendhau, R.C. Denny, J. D. Barues, M.J.K. Thomas

Semester-III

SPECIALIZATION: ORGANIC CHEMISTRY

Paper V **MCHP-311**

ORGANIC CHEMISTRY PRACTICAL

Objective: The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for synthesis of organic compounds, estimation of glycine. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes.

Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.

Syllabus Practical

1. Multistep synthesis of organic compounds
2. Estimation of sulfur in organic compounds
3. Estimation of glycine amino acid.

Recommended books

2. Vogal Textbook of quautitive chemical analysis (6th Edition) .J. Mendhau, R.C. Denny, J. D. Barues, M.J.K. Thomas

SEMESTER-III

Paper-VI **MCHP-312**

Project/Dissertation

This course will provide you with guidance and support throughout the writing of your dissertation. From discussing your initial ideas of your dissertation through the process of actually writing the document, this course will provide you with the information and support required from both the teaching staff and your allocated dissertation supervisor.

SEMESTER-IV

Paper I | **MCHC-401**

Spectroscopy II

Objectives: Principles and instrumentation of different molecular spectroscopic methods. • Qualitatively predict which signals are to be observed in the mass, NMR or ESR of Mossbauer Spectroscopy.

Outcomes: On completion of the course, students should be able to:

Combine, evaluate and interpret information from the various spectroscopic techniques in determination of molecular structure

Syllabus

1. **Mass Spectrometry:**

Measurement technique (El, Cl, FD and FAB), Molecular base and molecular ions, various class of organic molecules, McLafferty re-Arrangement and retro-Diels-Alder Fragmentation, nitrogen rule and determination of molecular composition of organic compounds from mass spectra data.

2. **Nuclear magnetic resonance**

(A). ^{1}NMR: The spinning nuclei, Chemical shift and its measurement, factors affecting chemical shifts, anisotropic effect and shielding mechanism, interpretation of protons spin-spin coupling, coupling constant, Chemical and magnetic equivalence, first and non-first order spectra, Simplification of complex spectra and NOE deuterium exchange, application in structural determination of simple organic.

(B). ^{13}CNMR: General introduction, peak assignments, chemical shift, ^{13}C-^{1}H coupling, Off-resonance Decoupling, Deuterium, fluorine and phosphorus coupling, NOE and DEPT, 2D NMR: COSY, and HETCOR, Application to simple organic.

3. **Electron Spin Resonance Spectroscopy**

Basic principle, factor affecting value, isotropic and anisotropic hyperfine coupling constant, Application to organic free radical, Methyl Free Radical, Naphthalene and Benzene free radicals.

4. **Mossbauer Spectroscopy**

Theory, Instrumentation, Applications - isomer shift, nuclear quadrupole coupling and hyperfine interaction, Problems related to Mossbauer Spectroscopy

Recommended books:

1. Spectroscopy by H. Kaur
2. Molecular Spectroscopy by Benwell
3. Spectroscopy by B.K. Sharma
4. Vibrational Spectroscopy theory and applications by D.N. Santhyanarayana

SEMESTER-IV

PAPER II **MCHC-402**

Recent trends-II

Objective: This course is framed to provide an in depth understanding of some important aspects of metal ions in biological system.

Outcome: Learning the important role of metal ions in biological systems will create interest to pursue research work in related field.

Syllabus

1. **Transport and Storage of Dioxygen:**

   Heme-proteins and oxygen uptake, Structure and function of hemoglobin, myoglobin, hemocyanine and hemerythrin.

2. **Metals in Medicine**

   Metal deficiency diseases, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

3. **Photochemistry:**

   Principles of photochemical reactions; orbital symmetry considerations, excited states and their properties; experimental set up for photochemical reactions; and their applications in organic synthesis Norrish type I and II reaction, Photoreduction, Photochemical aromatic substitution reaction, Reactions with singlet oxygen, Barton Reaction.

4. **Sonochemistry**

   Sound properties, Bubble formation, Ultrasound, principles of Sonochemistry and acoustic cavitation, Interfaces and Bubbles, Sonoluminescence, Bubble Temperature Estimation Homogeneous (liquid-phase) and heterogeneous (solid surface-liquid, particle liquid and liquid-liquid) reactions.

Recommended books

1. Practical Sonochemistry: Power Ultrasound Uses and Applications (Horwood Chemical Science) 2nd Edition by T J Mason. D Peters
2. Fundamentals of Photochemistry by Rohatgi, K.K.
3. Biological Inorganic Chemistry by Joan Selverstone Valentine.
4. Inorganic Biochemistry 2nd Ed by J. A. Cowan.
5. Bioinorganic Chemistry by Ivano Bertini; Harry Gray; Stephen J.
6. Principles of Bioinorganic Chemistry by Stephen J

SEMESTER-IV	
SPECIALIZATION: PHYSICAL CHEMISTRY	
PAPER III	**MCHE-403**
Chemical Kinetics and Reaction Dynamics	
Objectives: The advanced theories of chemical kinetics, Solid State, Reaction Dynamics, Statistical Treatment of Unimolecular reaction. **Outcomes:** On completion of the course, students should be able to: Explain fundamental aspects of kinetics. Explain the Chemical Reactions Autocatalysis, Schottky and Frankel Defects, Intermolecular, potential, potential energy surfaces, RRKM theory and advances made by Slater.	
Syllabus **Unit-1 Chemical Kinetics:** The study of fast reaction: Flow system, Relaxation and shock tube methods, Flash photolysis Oscillatory Chemical Reactions Autocatalysis, Autocatalytic Mechanisms of oscillatory chemical reaction: The lotka Volterra mechanism, The Brusselator, the Oregonator, Bistability and Chemical chaos. **Unit-2** Solid State Thermodynamics of Schottky and Frankel Defects, Solid State Reactions. **Unit-3** Statistical Treatment of Unimolecular reaction Limitation of Lindermann theory, Hinshelwood treatment, RRK theory (salient features and limitations) RRKM theory and advances made by Slater. **Unit-4** Reaction Dynamics Collision cross-section, Intermolecular potential, potential energy surfaces and elastic molecular collisions.	
Recommended books	

SEMESTER-IV	
SPECIALIZATION: PHYSICAL CHEMISTRY	
PAPER IV	**MCHE-404**
Statistical Mechanics	
Objectives: To understand the properties of macroscopic systems using the knowledge of the properties of individual particles. **Outcomes:** On completion of the course, students should be able to: Explain fundamental aspects of Statistical Mechanics, Distributions & Thermodynamics, Determination of Partition functions, Applications	
Syllabus	

Unit-1 Basis of Classical Statistical Mechanics:

Phase space, Ensembles, Ensemble–average, Liouvilles theorem, Quantum Picture, Basic postulates, classical limit, Quantisation of phase space, Distribution laws: Energy levels, Boltzmann distribution law, Fermi – Dirac statistics Bose – Einstein Statistics.

Unit-2 Distributions & Thermodynamics:

The partition function, relation of the partition functions to the thermodynamic function.

Unit-3 Determination of Partition functions:

Localised and non–localised systems, Separation of the partition function, Translational partition function, The Sackur Tetrode equation, Rotational partition function, vibrational partition functions, Electronic partition function, Derivation of thermodynamic properties of ideal gases from partition functions.

Unit-4 Applications:

Equilibrium Constants from partition function for: Isomerization equilibrium, Ionization equilibrium ($H \leftrightarrow H^+ + e$), and Dissociation equilibrium ($Na_2 \leftrightarrow 2Na$)

Recommended books:

1. Physical Chemistry By Ira Levine
2. Textbook Of Physical Chemistry By Maron S.H
3. Advanced Physical By Gurtu Gurtu
4. Physical Chemistry Thermodynamics, Statistical Mechanics, And Kinetics Andrew Cooksy

SEMESTER-IV

SPECIALIZATION: INORGANIC CHEMISTRY

PAPER III	**MCHE-405**

ORGANOTRANSITION METAL CHEMISTRY

Objectives: To understand the properties of Carbenes and Carbynes, Transition Metal π-Complexes, Catalysis involving organometallic compounds, Fluxional Organometallic Compounds.

Outcomes: On completion of the course, students should be able to: Explain fundamental aspects of Carbenes and Carbynes, Transition Metal π-Complexes, Catalysis involving organometallic compounds, Fluxional Organometallic Compounds.

Syllabus

1. Compounds of Transition Metal - Carbon Multiple Bond: Carbenes and Carbynes

Low valent carbenes and carbines, synthesis, nature of bond and Structural Characteristics.

2. Transition Metal π-Complexes

(a) Preparations, Important reactions relating on the ligands, Structural features and bonding of alkenes, allynes, alkyls, diene, dienyl, arene complexes, MO approach of bonding in ferrocene..

3. Catalysis involving organometallic compounds,

Olefin hydrogenation, Oxo reaction, Fischer Tropsch process, Wacker process, Polymerization of olefins,

4. Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^3 - allyl and η^3 dienyl complex.

Books Recommended:

1. Comprehensive Organometallic Chemistry, Ed. E.W. Abel, Abel, F.G.A. Stone and G. Wilkinson, Pergamon, 1982.
2. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, `Wiley, 1999.
3. The chemistry of elements, N.N. Greenwood and A. Earnshaw, 1997.
4. Inorganic Chemistry, principles of structure and reactivity. J.E. Huheey, Harper, 1983.
5. Organometallic Chemistry (A unified approach), R.C. Mehrotra and A. Singh, Wiley Eastern, 1991

SEMESTER-IV

SPECIALIZATION: INORGANIC CHEMISTRY

PAPER IV | **MCHE-406**

BIOINORGANIC CHEMISTRY

Objective: to provide the basic concepts of Metalloenzymes, Electron Transfer in Biology, Nitrogenase, Metal Storage, Transport and Biomineralization

Outcome: Students will gain the fundamental knowledge about the Metalloenzymes, Electron Transfer in Biology, Nitrogenase, Metal Storage, Transport and Biomineralization. Exposure to the fundamental concepts on different theories of bonding and their relation to the properties of transition metal coordination compounds will be helpful in understanding the role of this class of compounds in different fields of application like in Bioinorganic Chemistry for future study.

Syllabus

1. Metalloenzymes

Zinc enzymes - carboxypeptidase, carbonic anhydrase; Copper enzymes – superoxide dismutase; Coenzyme vitamin B_{12}.

2. Electron Transfer in Biology

Structure and function of metalloproteins in electron transport process - cytochromes and iron, Sulphur proteins.

3. Nitrogenase

Biological nitrogen fixation, molybdenum nitrogenase.

4. Metal Storage, Transport and Biomineralization

Ferritin, transferrin and siderophores

Books Recommended:

1. Bioinorganic Chemistry. R. N. Hay. Wiley. 1984.
2. The Inorganic Chemistry of Biological Processes. M. M. Hughes. Wiley 1981.
3. An Introduction to bioinorganic Chemistry. El Ichiro ochai. Allyn. 1977.
4. Inorganic Chemistry: Principles of structure and reactivity. J.E. Huheey Harper. 1983.
5. Advanced inorganic Chemistry. F.A. Cotton and G. Wilkinson. Wiley. 1999.

SEMESTER-IV

SPECIALIZATION: ORGANIC CHEMISTRY

PAPER III **MCHE-407**

Organic Synthesis

Objectives: This course aims to impart to the student, knowledge of Protection and Deprotection of groups, Selective name reactions, Oxidation, Reduction mechanism and the importance of chirality in organic synthesis. Multi-component reactions as a tool for efficient atom economical reactions.

Learning Outcomes: On completion of the course, the student should be able to Understand the importance of organic synthesis and propose syntheses of molecules with control of the stereochemistry. Design chemical processes and products that eliminate the use or generation of hazardous substances.

Syllabus

1. **Protection and Deprotection of groups**:
   Principles of protection and deprotection of alcohols, 1,2- and 1,3-diols, amines, carbonyls and carboxyl groups in organic synthesis.
2. **Selective name reactions** and their application in organic synthesis: Reformatsky, Michael addition, Robinson annelations, Peterson Olefination, Shapiro, Hoffman reaction, Baylis-Hillman Reaction, Coupling Reactions (Suzuki Coupling, Sonogashira Coupling),
3. **Oxidation**: Mechanisms and application of: SeO_2, Jones reagent, Pyridinium chlorochromate (PCC), Corey-Kim Oxidation, Swern Oxidation, Dess-Martin Oxidation, Davis Oxidation, m-CPBA
4. **Reduction:** Mechanism and stereochemistry of reduction with following reagents:
   $NaBH_4$, LAH, DIBAL, diborane, and 9BBN, Mechanism of metal hydride reduction of saturated / unsaturated compounds, Birch reduction,

SEMESTER-IV

SPECIALIZATION: ORGANIC CHEMISTRY

PAPER IV **MCHE-408**

SELECT TOPICS IN ORGANIC CHEMISTRY

Objectives: This course aims to impart to the student, knowledge of: Synthesis, properties and reactions of 3-, 4-, 5-, 6-, 7- and 8-membered heterocyclic compounds. • applications of Retro-Synthesis, to study the Carbohydrates and Synthetic Drugs.

Outcomes: On completion of the course, students should be able to: Rationalize the synthesis, structure and applications of organometallic compounds for organic transformations. • Design the synthesis of industrially important compounds.

Syllabus

1. **Heterocycles**
   a. General introduction and nomenclature
   b. Chemistry of
      (i) Five membered: Pyrazole and imidazole, oxadiazole and thiadiazole .
      (ii) Six membered: Pyrazine, pyrimidine and pyridiazine
2. **Retro-Synthesis:** Introduction to synthons and synthetic equivalents, disconnection approach, functional group interconversions. One group C-X and two groups C-X disconnection, Chemoselectivity.
3. **Carbohydrates:** Structure elucidation of Disaccharides: maltose, sucrose. Structure, function and configuration of Polysaccharides: Cellulose, Starch..
4. **Synthetic Drugs:** A general study of important synthetic drugs of the following types:
   Sulpha drugs: Sulphanilamide derivatives, sulphathiazole,, sulphasuccidine, sulphaguanidine, sulphadiazine. **Antimalarials:** 4-Aminoquinoline derivatives, chloroquine, santoquine, 8-aminoquinoline.
   Anti-cancer agents: Nitrogen mustards, antimetabolites in cancer chemotherapy.
   Antitubercular agents: PAS, Thiosemicarbazones, hydrazides and thiocarbanilides.

Recommended book

- Heterocyclic Chemistry by Bansal, Raj K
- Fundamentals Of Heterocyclic Chemistry Importance In Nature And In The Synthesis Of Pharmaceuticals by Louis D Quin
- Principles Of Pharmaceutical Organic Chemistry 2/E by Nadendla
- Organic Chemistry by Subrata Sengupta

SEMESTER-IV

SPECIALIZATION: PHYSICAL CHEMISTRY

Paper V **MCHL-409**

PHYSICAL CHEMISTRY PRACTICAL

Objective: To empower students to carry out, and interpret measurements within the context of the fundamental technological problem with which they are presented. The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for qualitative and quantitative analysis and characterizations using chemical and spectral and other modern techniques. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes. Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.

Syllabus

1. **Chemical Kinetics:**
   - 1.1 Determination of rate constant of acid Hydrolysis of ester
   - 1.2 Relative Strength of strong acids by studying the kinetics of hydrolysis of ester
   - 1.3 Kinetics of reactions between Potassium Persulphate and Potassium iodide.
   - 1.4 Kinetics of iodination of acetone
2. Optical Methods:
   - 2.1 Colorimetry : Verification of Lambert's Beer Law
   - 2.2 Refractometry
   - 2.3 Spectroscopic methods of analysis: UV-Visible, IR
   - 2.4 Polarimetry

Recommended book

- Experimental Physical Chemistry by Professor V D Athawale, Parul Mathur.
- Physical Chemistry Practical by Kamala Rani Bhattacharyya
- Advanced Practical Physical Chemistry By J.B. Yadav

SEMESTER-IV

SPECIALIZATION: INORGANIC CHEMISTRY PRACTICAL

Paper V **MCHL-410**

Inorganic Chemistry Practical

Objective: The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for qualitative and quantitative analysis, preparation of metal complexes. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes.

Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization which provides deeper understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.

Syllabus

1. **Potentiometry:**
   a. Acid-Base, Redox Titrations.
   b. Determination of stability constants of suitable complex systems.
2. Conductometry

Acid-Base and precipitation Titrations

3. Colorimetry and Spectrophotometry:

Estimation of the following metals in solution V, Cr, Mo, Fe and Ni.

4. Flame Photometry:
   a. Estimation of sodium and potassium in admixture.
   b. Estimation of magnesium and calcium in tap water.
   c. Estimation of calcium in calcium salt solution.

SEMESTER-IV

SPECIALIZATION: ORGANIC CHEMISTRY PRACTICAL

Paper V **MCHL 411**

Organic Chemistry Practical

Objective: The aim and objective of the practical course is to imbibe and develop practical skills, confidence and compliance for synthesis of organic compounds, estimation of glycine. Besides, induce a vision to see the scope in R & D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyzes and optimize necessary process parameter in kinetic and thermodynamics processes.

Students acquire all essential practical skills and learn techniques through Multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization which provides deeper

understanding of subject and confidence for implementation of newer ideas helping them to pursue higher education and R&D activities.
Syllabus 1. Analysis of ternary organic mixture 2. Estimation of glucose
Recommended book • Vogels Textbook Of Practical Organic Chemistry by Furniss And Brian S And Hannaford And Antony J • Practical Organic Chemistry by Mann & Saunders • Advanced Practical Organic Chemistry by John Leonard, Barry Lygo, Garry Procter

SEMESTER-IV	
Paper-VI	**MCHP-412**
Project/Dissertation This course will provide you with guidance and support throughout the writing of your dissertation. From discussing your initial ideas of your dissertation through the process of actually writing the document, this course will provide you with the information and support required from both the teaching staff and your allocated dissertation supervisor.	

Evaluation of theory paper

Each theory and practical paper has 100 marks

i. **Internal 25 marks** (10 marks of a written test, 10 marks of assignment and 5 marks for the student attendance and performance).

ii. **Theory exam 75 marks.**

Pattern of paper

1. Paper contain 5 questions of 15 marks each. Time of exam will be 3 hours.
2. Question no 1 is compulsory and divided into 5 parts (such as a, b, c, d and e) each is 3 marks.
3. Question No 2 and 3 will be the long question and have 15 marks each.
4. Question no 4 and 5 devided into two parts (such as a and b) & each is 7 and 8 marks.

Evaluation of Practical paper

i. **Internal 25 marks** (10 marks of a written test, 10 marks of assignment and 5 marks for the student attendance and performance).

ii. **Practical exam 75 marks**

1. Practical Time: 12h in two days.
2. 3 Practical will be done in two days.

3. Each practical will be 15 marks
4. Viva-voce will be 20 marks.
5. Practical record will be 10 marks.

Evaluation of Project paper

1. On the basis of research project done in both semesters, the prepared project report/dissertation will be evaluated by external and internal examiners in 50 marks separately. The student will be evaluated for 25 marks on the basis of concerned viva voce from his research project.
2. Remaining 25 marks will be awarded to the student only when he will publish his research paper related to his research project in UGC care listed journal

Azad Kumar Shilpi L. Singh

Dr. Azad Kumar Dr Shilpi Srivastava Dr. Laxman Singh