MANGALAYATAN UNIVERSITY, ALIGARH

CENTRE FOR DISTANCE AND ONLINE EDUCATION

PROGRAMME PROJECT REPORT

MASTER OF SCIENCE (CHEMISTRY)

M.Sc. (Chemistry)

2023-24

Introduction

Master of Science in Chemistry (M.Sc. Chemistry) is a postgraduate program that delves into advanced chemical concepts and theories. This program is meticulously crafted to empower students with a profound comprehension of various chemical principles and their wide-ranging applications across various domains, including pharmaceuticals, materials science, environmental science, and chemical engineering. The comprehensive curriculum encompasses advanced topics such as quantum chemistry, chemical thermodynamics, spectroscopy, organic synthesis, and chemical kinetics, among others. Through M.Sc. Chemistry program, students not only acquire theoretical knowledge but also gain practical laboratory skills, enabling them to conduct cutting-edge research and contribute to advancements in the field of chemistry.

M.Sc. Chemistry students are encouraged to engage in independent research projects and collaborative endeavours, fostering the development of vital teamwork and communication abilities. They are introduced to state-of-the-art laboratory techniques and modern analytical instruments, which further bolster their problem-solving prowess. Moreover, this program emphasizes the application of chemical knowledge in real-world scenarios, fostering the development of innovative solutions to complex challenges. Graduates of M.Sc. Chemistry program emerge as highly skilled chemists, well-prepared to pursue careers in academia, research and development, pharmaceuticals, chemical manufacturing, and various other sectors where a profound understanding of chemistry is indispensable. This rigorous and fulfilling program offers students a solid foundation in chemistry, positioning them for a diverse array of exciting career prospects in the dynamic field of chemistry.

A. Programme's Mission and Objectives

Mission

- To cater and ensure excellent theoretical and practical training through teaching, counseling, and mentoring with a view to achieve professional and academic excellence.
- To connect with industry and incorporating knowledge for research enhancement.
- To generate, disseminate and preserve knowledge for the benefit and betterment of society.

Objectives

M.Sc. in Chemistry programme has a comprehensive set of objectives aimed at providing students with a deep and advanced understanding of the field. It seeks to instill a strong foundation in core chemical principles and theories while promoting critical thinking and analytical skills. Additionally, the programme aims to cultivate students' ability to conduct independent research, including honing skills in literature review, experimental design, data analysis, and effective scientific communication. It aligns its curriculum with the evolving needs of industries and academia to ensure graduates are well-prepared for diverse career opportunities, spanning academia, research, pharmaceuticals, environmental science, and various other sectors. Ultimately, the programme contributes to the advancement of scientific knowledge and innovation within the realm of chemistry.

B. Relevance of the Programme with HEI's Mission and Goals

The vision and mission of HEI, Mangalayatan University, Aligarh are:

Vision:

To be an institution where the most formative years of a young mind are spent in the guided pursuit of excellence while developing a spirit of inquisitive questioning, an ability to excel in the pressure of a fast-changing professional world, and a desire to grow into a personality rather than a person, in an environment that fosters strong moral and ethical values, teamwork, community service and environment consciousness.

Mission:

- To be the enablers of the confluence of academic rigor and professional practicality.

- To bring global best practices to students through widespread use of technology.
- To empower our faculty to constantly develop new skills and excel professionally.
- To provide the best campus environment to students and faculty with all facilities to nurture their interest.

M.Sc. (Chemistry) programme of the University strives to realize its vision and mission by rectifying student centric issues on priority and also to empower local community with the help of various social clubs running in University like NSS, KADAM and Alumni association. The University promotes multidisciplinary and allied research in various fields that supports and harnesses joyful learning environment. The goals of ODL (Open Distance Learning) program is to provide educational facilities to all qualified and willing persons who are unable to join regular courses due to personal or professional reasons. There are many potential learners who cannot afford to join regular courses due to professional responsibilities and personal commitments. For such cases M.Sc. (Chemistry) through ODL mode can be helpful in increasing knowledge base and skill up-gradation.

The programme aims to provide alternative path to wider potential learners who are in need of refresher courses to update their skills.

C. Nature of Prospective Target Group of Learners

Distance Education of Mangalayatan University (MU) shall target the working professional's executives as well as those who cannot attend a full-time program due to prior occupation or other assignments. The candidates desirous of taking admission in M.Sc. (Chemistry) programme shall have to meet the eligibility norms as follows-

1. To obtain admission in M.Sc. (Chemistry) programme offered through ODL mode.
2. The learner must have completed graduation in science stream (PCM/PCMB).

D. Appropriateness of Programme to be conducted in ODL mode to acquire specific skills and competence

The University has identified the following **Programme Outcomes** and **Programme Specific Outcomes** as acquisition of specific skills and competence in M.Sc. (Chemistry) Programme.

Programme Outcomes (PO's)

After completing the M.Sc. (Chemistry) programme through ODL Mode, students will be able to:

a. PO1: Knowledge outcomes: Acquire knowledge and ability to develop creative solutions, and better understanding of the future developments of the subject. Also evolve analytical and logical thinking abilities.
b. PO2: Skill Outcomes: Learn and understand the new concepts and get prepared for placement by developing scientific skills. Further ability to communicate scientific information in a clear and concise manner.
c. PO3: General Competence: Be able to understand the role of science in solving real life problems and get an ability to participate in debates and discussions constructively.
d. PO4: Scientific Aptitude and Innovation: Know the recent developments, future possibilities and able to gather, assess, and make use of new information and applying this knowledge to find creative solutions.

Programme Specific Outcomes:

After completing the M.Sc. (Chemistry) programme through ODL Mode, students will be able to:

a. PSO1: Students will understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life. They will also be

able to acquire knowledge about the fundamentals and applications of chemical and scientific theories.

b. PSO2: Helps in understanding the causes of environmental pollution and can open up new methods for environmental pollution control.
c. PSO3: Students will become familiar with the different branches of chemistry like analytical, organic, inorganic, physical, environmental, polymer and biochemistry. They will also learn to apply appropriate techniques for the qualitative and quantitative analysis of chemicals in laboratories and in industries.
d. PSO4: Provide a systematic understanding of the concepts and theories of chemistry and their application in the real world – to an advanced level, and enhance career prospects in a huge array of fields.

E. Instructional Design

The programme is divided into four semesters and minimum credit requirement is 80 to get M.Sc. (Chemistry) degree in ODL mode from Mangalayatan University. Minimum time period for acquiring M.Sc. (Chemistry) degree will be two years and maximum time period to acquire is 4 years.

Evaluation Scheme

Semester-I							
S. No.	**Course Code**	**Course Name**	**Category**	**Credit**	**Continuous Assessment Marks**	**Term End Exam Marks**	**Grand Total**
					Max. Marks	**Max. Marks**	
1	CHL-6111	Instrumental Chemistry of Analysis	DCC	4	30	70	100
2	CHL-6112	Stereo Chemistry and Organic Reaction Mechanism	DCC	4	30	70	100
3	CHL-6113	Quantum Chemistry	DCC	4	30	70	100
4	CHL-6114	Photochemistry and Pericyclic Reactions	DCC	4	30	70	100
5	CHL-6115	Main Group of Chemistry	DCC	4	30	70	100
6	CHP-6111	Chemistry Lab-I	DCC	2	0	100	100
7	CHP-6112	Chemistry Lab-II	DCC	2	0	100	100
Total				24	150	550	700

Semester-II

S. No.	Course Code	Course Name	Category	Credit	Continuous Assessment Marks	Term End Exam Marks	Grand Total
					Max. Marks	Max. Marks	
1	CHL-6211	Molecular Thermodynamics	DCC	4	30	70	100
2	CHL-6212	Organic Synthesis	DCC	4	30	70	100
3	CHL-6213	Transition and Inner Transition Metal Chemistry	DCC	4	30	70	100
4	CHL-6214	Basic Organometalic Chemistry	DCC	4	30	70	100
5	CHL-6221	Supramolecular Chemistry	DCC	3	30	70	100
6	CHP-6211	Chemistry Lab-III	DCC	2	0	100	100
7	CHP-6212	Chemistry Lab-IV	DCC	2	0	100	100
Total				23	150	550	700

Semester-III							
S. No.	**Course Code**	**Course Name**	**Category**	**Credit**	**Continuous Assessment Marks**	**Term End Exam Marks**	**Grand Total**
					Max. Marks	**Max. Marks**	
1	CHL-7111	Bioinorganic and Biophysical Chemistry	DCC	4	30	70	100
2	CHL-7112	Analytical Techniques	DCC	4	30	70	100
3	CHL-7113	Organic Photochemistry	DCC	4	30	70	100
4	CHL-7121	Solid State Chemistry	DCC	3	30	70	100
5	CHD-7111	Project-I	DCC	4	0	100	100
Total				19	120	380	500

Semester-IV

S. No.	Course Code	Course Name	Category	Credit	Continuous Assessment Marks	Term End Exam Marks	Grand Total
					Max. Marks	Max. Marks	
1	CHL-7211	Inorganic Polymers	DCC	4	30	70	100
2	CHL-7221	Statistical Thermodynamics	DCC	3	30	70	100
3	CHL-7222	Chemistry of Natural Product	DCC	3	30	70	100
4	CHD-7211	Project-II	DCC	4	0	100	100
Total				14	60	310	400

MOOCs

The University shall give flexibility in opting for MOOCs (Massive Online Open Courses) by the students pertaining to the prescribed curriculum and also the credits earned in the MOOCs may be dealt as part of the evaluation scheme as per UGC (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020.

Syllabi and Course Materials

Syllabi, PPR and self-learning materials are developed mostly by experienced faculty members of Mangalayatan University in consultation with contents experts and the same will be forwarded to CIQA and BoS/Academic Council/ Executive Council for further suggestions and approval.

Semester: I

Course Name: Instrumental chemistry of analysis **Code: CHL-6111**
Credits: 4

Course Objectives:

The objective of the course is to explain the general concept of analytical techniques and related methods. The interpretation of data using various types of spectroscopy such as atomic absorption spectroscopy, emission spectroscopy, Nuclear magnetic spectroscopy, mass spectroscopy and x-ray spectroscopy, and their applications in different fields is also the mail goal of this course.

Block I: General Introduction to Analytical Methods
Units 1: Measurement Basics and Data Analysis, Classification and Selection of Analytical Methods, Types and Calibration of Instruments, Signals and Noise, Linear and Nonlinear Regression Analysis.
Unit 2: Introduction to Spectrometric Methods: General properties of electromagnetic radiation
Unit 3: Basic elements of spectroscopy and its advantages, einstein coefficients.

Block II: Spectroscopic Analysis
Unit 4: Atomic Absorption, Spectrometry: Sample Atomization Techniques, Atomic Absorption Instrumentation, Interferences in Atomic Absorption Spectroscopy, Atomic Absorption Analytical Techniques,

Unit 5: Fluorescence, Emission Spectroscopy: Atomic Fluorescence Spectroscopy, Emission Spectroscopy Based on Plasma Sources, Emission Spectroscopy Based on Arc and Spark Sources.
Unit 6: Mass, and X-Ray Spectroscopy: Introduction to Atomic Mass and X-Ray Spectrometry.

Block III: UV-VIS and Raman Spectroscopy
Unit 7: UV-VIS Molecular Absorption Spectrometry: Measurement of Transmittance and Absorbance, Beer's Law, The Effects of Instrumental Noise on Spectrophotometric Analyses, Instrumentation, The Magnitude of Molar Absorptivity's, Absorbing Species.
Unit 8: Application of Absorption Measurement to Qualitative Analysis, Quantitative Analysis by Absorption Measurements, Photometric Titrations.
Unit 9: Raman Spectroscopy: Theory of Raman Spectroscopy, Instrumentation, Applications of Raman Spectroscopy, Types of Raman Spectroscopy.

Block IV: Infrared Spectrometry and thermogravimetric analysis
Unit 10: Theory of Infrared Absorption Spectrometry, Infrared Sources and Transducers, Infrared Instruments.
Unit 11: Application of Infrared spectroscopy, Photoacoustic Infrared Spectroscopy, Near-Infrared Spectroscopy.
Unit 12: Thermogravimetric (TG) analysis

Block V: NMR and Mass Spectroscopy
Unit 13: Nuclear Magnetic Resonance Spectroscopy: Theory of Nuclear Magnetic Resonance (NMR), Environmental Effects on NMR Spectra, NMR Spectrometers, Applications of Proton NMR.
Unit 14: Carbon13 NMR, Application of NMR to Other Nuclei, Two-Dimensional Fourier Transform NMR, Magnetic Resonance Imaging.
Unit 15: Mass Spectrometry: Molecular Mass Spectra, Ion Sources, Mass Spectrometers, Applications of Molecular Mass Spectrometry, Quantitative Applications of Mass Spectrometry.

Books Recommended/Suggested Reading:

1. *Skoog, D. A.; Holler, F. J.; Nieman, T. A. Principles of Instrumental Analysis, 5th Ed., Thomson Brooks/Cole, 1998.*
2. *Strobel, H. A.; Heineman, W. R. Chemical Instrumentation: A Systematic Approach, 3rd Ed., John Wiley and Sons, 1989.*
3. *Willard, H. H.; Merritt, Jr., L. L.; Dean, J. A.; Settle, Jr., F. A. Instrumental Methods of Analysis, 7th Ed., Wadsworth, 1988.*
4. *Rubinson, K. A.; Rubinson, J. F. Contemporary Instrumental Analysis , 1st Ed., Prentice Hall, 2000.*
5. *Rouessac, F.; Rouessac, A. Chemical Analysis: Modern Instrumentation Methods and Techniques, 4th Ed., John Wiley and Sons, 1998.*
6. *Settle, F. A. Handbook of Instrumental Techniques for Analytical Chemistry, 1st Ed., Prentice Hall, 1997.*
7. *Kaur, H. Instrumental Methods of Chemical Analysis, 1st Ed., Pragati Prakashan, 2001.*
8. *Ewing, G. W. Instrumental Methods of Chemical Analysis, 5th Ed., Mcgraw-Hill, 1985.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Understand the basic concept of analytical methods.
2. Define emission and absorption spectroscopy and their applications.
3. Explain the absorption peaks using UV-Visible spectroscopy.

4. Identify infrared Spectrometry and thermogravimetric analysis.
5. Interpret NMR and Mass Group Spectrometry.

Course Name: Stereo Chemistry and Organic Reaction Mechanism **Code: CHL-6112**
Credit: 4

Course Objectives:

Organic chemistry plays an important role in different streams of science. The study of structure of different organic isomers using isomerism is the important concept. Therefore, the aim of this course is to explain the concept of optical isomerism and stereochemistry of bridged, caged and cyclic compound. Any reaction is not possible without reaction mechanism and intermediates. Hence, the detail study of various intermediates as well related mechanism is also the goal of this study.

Block I: Stereoisomerism: Optical Isomerism

Unit 1: Stereoisomers, symmetry elements, chiral molecules with one stereogenic centre: optical activity, sequence rules, absolute configuration, enantiomeric excess.

Unit 2: Molecules with two (or more) stereogenic centres: diastereomers, Newman, Fischer and Sawhorse formulae.

Unit 3: Erythro/threo, syn/anti configurations, meso configuration.

Block II: Stereochemistry: fused, bridged, and caged ring systems

Unit 4: Stereochemistry of fused, bridged, and caged ring systems

Unit 5: Resolution of enantiomers.

Unit 6: Chirality without stereogenic carbon: allenes, biphenyls, cyclophanes, helicenes, atropisomerism.

Block III: Steroisomerism: Cyclic structures

Unit 7: Steroisomerism in cyclic structures: cyclopropane, cyclobutene, cyclopentane.

Unit 8: Cyclohexane, decalins, anomeric effect, conformational analysis.

Unit 9: Prochirality, enantiotopic and diasterotopic groups and faces.

Block IV: Reaction Intermediates

Unit 10: Reactive intermediates: carbocations, carbanions.

Unit 11: Enolates, Carbenes, nitrenes, benzyne.

Unit 12: Free radicals, Kinetic and Thermodynamic control of reactions.

Block V: Reaction Mechanism

Unit 13: Reaction mechanism: substitutions, eliminations reactions.

Unit 14: Additions, rearrangements.

Unit 15: The Hammett relationship, stereochemistry and mechanism.

Books Recommended/Suggested Reading:

1. *F. A. Carey and R. J. Sundberg, "Advanced Organic Chemistry, Part A", fifth edition, Springer.*
2. *E. L. Eliel, "Stereochemistry of Organic Compounds", John Wiley & Sons.*
3. *J. March, "Advanced Organic Chemistry", fifth edition, John Wiley & Sons.*
4. *J. Clayden, N. Greeves and S. Warren, "Organic Chemistry", Second Edition, Oxford University Press.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Classify Stereoisomers.
2. Explain stereochemistry of fused, bridged, and caged ring systems.
3. Interpret Stereoisomerism in cyclic structures.
4. Define Reaction intermediates.
5. Identify reaction mechanism.

Course Name: Quantum Chemistry **Code: CHL-6113**
Credits: 4

Course Objectives:

Quantum chemistry is an important branch of Chemistry which delas at the small systems. Various phenomenon such as black body radiations, photoelectric effect, Heisenberg's uncertainty principle etc. are some important concepts in quantum mechanism. The use of Schrodinger wave equation for one electron as well as multi electron system is the main objective of this study. Using the wave function, the molecular orbital diagram as well as Huckel's energy level diagram can also be explained for various acyclic and cyclic systems.

Block I: Introduction to quantum mechanism
Unit 1: Dawn of Quantum Mechanics: black-body radiation, heat capacities, photoelectric and Compton effects.
Unit 2: Atomic and molecular spectra, particle diffraction, wave-matter duality.
Unit 3: Foundation of Quantum Theory: Postulates of quantum mechanics, operators, specification and evolution of states.

Block II: Schrodinger wave equation and its applications
Unit 4: Schrodinger wave equation, physical significance of wave function
Unit 5: Translational Motion: Particle-in-a-box, penetration into and through barriers.
Unit 6: Harmonic Oscillator Rotational Motion: Particle-on-a-ring, particle-on-a-sphere, motion in a coulombic field.

Block III: Hydrogen atom
Unit 7: Hydrogenic Atoms and Angular Momentum.
Unit 8: Many Electron Atoms.
Unit 9: Approximate Methods: Perturbation theory and variational methods.

Block IV: Molecular structure
Unit 10: Introduction to Molecular Structure: Born-Oppenheimer approximation, molecular orbital theory.
Unit 11: Valence bond theory.
Unit 12: Computational Chemistry: Semi-empirical and *ab initio* methods.

Block V: Huckel Theory
Unit 13: Huckel's theory, resonance integral, energy level diagram for ethene, cyclobutadiene, allyl system, butadiene, benzene.

Unit 14: Delocalization energy of ethene, cyclobutadiene, benzene, allyl cation, allyl radical, allyl anion, cyclopropyl anion, cyclopropyl radical and cyclopropyl cation.
Unit 15: Huckel's molecular orbital wave function for ethene, allyl cation, cyclobutadiene, benzene. Electron density and bond order.

Books Recommended/Suggested Reading:

1. *Quantum Chemistry, Donald A. McQuarrie, Viva Books.*
2. *Modern Quantum Chemistry, Attila Szabo & Neil S. Ostlund, Dover Publications.*
3. *Quantum Chemistry, Ira N. Levine, PHI Learning.*
4. *Quantum Chemistry and Molecular Interactions, Andrew Cooksy, Pearson Press.*
5. *Quantum Chemistry & Spectroscopy, Thomas Engel, Pearson Education.*
6. *Molecular Quantum Mechanics, Peter Atkins & Ronald Friedman, Oxford Press.*
7. *Elementary Quantum Mechanics, Frank L. Pilar, Dover Publications.*
8. *Fundamentals of Quantum Chemistry, James E. House, Elsevier/Academic Press.*
9. *Quantum Chemistry, John P. Lowe & Kirk A. Peterson, Elsevier/Academic Press.*
10. *Introduction to Quantum Chemistry, A. K. Chandra, Tata-McGraw Hill*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Explain origin of quantum chemistry.
2. Define the concepts and postulates of quantum mechanics.
3. Illustrate Schrodinger wave equation and its application to particle in a box and harmonic oscillator.
4. Interpret molecular orbital theory and valence bond theory.
5. Solve Huckel theory.

Course Name: Photochemistry and Pericyclic Reactions **Code: CHL-6114**
Credits: 4

Course Objectives:
The effect of light on the reaction mechanism and possible rearrangements is important concept in photochemistry. The photochemical laws and reactions using different conditions can be explained in various electron system. Therefore, the objective of this study is to explain the photochemistry and pericyclic reactions in 4n and 4n+2 electron systems.

Block I: Photochemistry: mechanism and rearrangements
Unit 1: Photochemical activation and potential energy surfaces. Geometry, dipole moments, acid-base and redox properties of excited states.
Unit 2: Uni- and bimolecular deactivations. Quenching mechanisms. Electronic energy transfer mechanisms.
Unit 3: Intramolecular (isomerizations, rearrangements and dissociation) and intermolecular (additions) photochemical processes.

Block II: Inorganic photochemistry
Unit 4: Introduction to inorganic photochemistry. Photochemical laws and photochemical kinetics.
Unit 5: Photophysical processes. The electronic absorption spectra of inorganic compounds. Characteristics of the electronically excited states of inorganic compounds.
Unit 6: Photo electro chemistry of excited state redox reactions. Photosensitization.

Block III: Photochemical reactions

Unit 7: Photochemical reactions; substitution, decomposition reactions, fragmentation, rearrangement, and redox reactions.

Unit 8: Selective inorganic photochemistry using laser beams.

Unit 9: Inorganic photochemistry in biological processes and their model studies.

Block IV: Molecular orbital approach and pericyclic reactions

Unit 10: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system.

Unit 11: Classificaiton of pericyclic reactions. Woodward -Hoffmann correlation diagrams. FMO and PMO approach.

Unit 12: Electrocyclic reactions- conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems.

Block V: Cycloaddition reactions

Unit 13: Cycloadditions - antarafacial and suprafacial additions, 4n and 4n+2 systems, 2 + 2 addition of ketenes, 1,3-dipolar cycloadditions and cheleotropic reactions.

Unit 14: Sigmatropic rearrangements - suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5 - sigmatropic rearrangements.

Unit 15: Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Books Recommended/Suggested Reading:

1. *Fundamental of Photochemistry, K.K. Rohtagi- Mukherji, Wily- Eastern.*
2. *Essentials of Molecular Photochemistry, A.Gilbert and J.Baggott, Blackwell Scientific Publication.*
3. *Molecular Photochemistry, N.J. Turro, W.A. Benjamin. R. B. Woodward and R. Hoffmann, "The Conservation of Orbital Symmetry", Academic Press, New York.*
4. *Introductory Photochemistry, A. Cox and T. CAMP, Mc Graw-Hill,*
5. *Photochemistry, R.P. Kundall and A. Gilbert, Thomson Nelson.*
6. *Organic Photochemistry, J. Coxon and b. Halton, Cambridge University Press.*
7. *Pericyclic Reactions, S.M. Mukherji, Macmillan, India*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Explain Photochemical mechanisms and rearrangements.
2. Define Inorganic photochemistry.
3. Illustrate photochemical reactions.
4. Interpret molecular orbital approach and pericyclic reactions.
5. Describe cycloaddition reactions

Course Name: Main Group Chemistry **Code: CHL-6115**

Credits: 4

Course Objectives:

In the periodic table elements are arranged according to their atomic number and the detailed study of these elements irrespective of the groups and periods is important. Therefore, this course aims to explain the general characteristics of s and p-block elements and their variation in the periodic table is

also explained in this course. The chemistry of phosphorous related compounds also discussed in this course.

Block I: Non-transition elements

Unit 1: Chemistry of non-transition elements, stereochemistry and bonding in non-transition elements and compounds.

Unit 2: Solvents, solutions, acids and bases, brief review of inorganic chains, rings and cages.

Unit 3: Organometallic compounds of non-transition elements, role of non-transition elements in biological processes.

Block II: s and p-Block elements: Group 1, 2, 13, 14 and 15

Unit 4: General properties of p block elements, bonding, historical landmarks, and periodic properties, Introduction to group theory.

Unit 5: Chemistry of alkali and alkaline earth metals.

Unit 6: Chemistry of group 13, 14, 15, and 16 elements. The nitrogen and oxygen groups: The nitrogen group with special emphasis on nitrogen and phosphorus chemistry; boron nitrogen compounds; nitrogen-metal complexes and bonding; phosphorus-metal bonds and complexes. The oxygen group with special emphasis on the chemistry of sulphur. p-block ring and cluster compounds.

Block III: Halogen Family

Unit 7: Chemistry of Halogen compounds

Unit 8: Polyhalogeno and interhalogen compounds

Unit 9: compounds of halogens and oxygen

Block IV: Noble Gases

Unit 10: Chemistry of rare gases.

Unit 11: Special topics and recent developments: Catenation between heavier elements, particularly, RE=ER (E = P, As, Sb, Bi), R2E=ER2 and R2E (E = Si, Ge, Sn, Pb) systems.

Unit 12: Multiple bonding between heavier elements

Block IV: Phospha-alkynes and phospha-alkenes

Unit 13: Phospha-alkynes and phospha-alkenes.

Unit 14: Chemistry of alkali and alkaline earth metals; their uses in homogeneous catalysis and material chemistry.

Unit 15: Main group organometallic chemistry. Unusual oxidation states of main group elements with special emphasis on recently developed Al(I) and Si(II)-silylene chemistry.

Books Recommended/Suggested Reading:

1. *Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.*
2. *Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.*
3. *Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970*
4. *Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.*
5. *Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.*
6. *Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.*
7. *Shriver & Atkins, Inorganic Chemistry 5th Ed.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Explain non-transition elements.
2. Define s and p block elements.
3. Interpret halogen compounds.
4. Illustrate Noble gases.
5. Identify Phospha-alkynes and phospha-alkenes

Course Name: Chemistry Lab-I **Code: CHL-6111**

Credits: 2

Course Objectives:

The objective of the course is to study the analysis of mixture of rare earth metals, and preparation of some inorganic as well as organic compounds.

1. Qualitative Analysis of Inorganic Mixture

Identification of 07 radicals including insoluble residue and rare earth metal ions by semi-micro analysis.

(i) Rare elements: Tl, W, Se, Mo, Ti, Zr, Ce, Th, V, U, Li

2. Preparations of some Inorganic Complex Compounds

(i) Tetrammine Cupric Sulphate

(ii) Prussian Blue (Potassium Ferric Ferro cyanide)

(iii) Reineckes salt [Ammonium diammine tetra thio cyanato chromate (III)]

3. Preparations

(i) To perform Bromination: 2, 4, 6-tribromoaniline from aniline

(ii) To perform Oxidation: Benzil from benzoin by means of cupric salts

4. Separation of dyes using TLC method.

5. Perform pH-metric and potentiometric titration of phosphoric acid solution against standard NaOH solution. Compare the two results.

SUGGESTED READINGS:

- Ozin G.A., Arsenault A.C. and Cademartiri L.: NANOCHEMISTRY: A CHEMICAL APPROACH TO NANOMATERIALS (2009).
- Sergeev G.B.: NANOCHEMISTRY, Elsevier, B.V. (2006).
- Day R.A. and Underwood A.L.: QUANTITATIVE ANALYSIS, Prentice Hall India Pvt. Ltd., New Delhi, 3rd Ed., (1997).
- Yadav J.B.: ADVANCED PRACTICAL PHYSICAL CHEMISTRY, Krishna Prakashan Media (P) Ltd., Meerut (2016).
- Jeffery G.H., Bassett J., Mendham J. and Denney R.C.: VOGEL'S TEXTBOOK OF QUANTITATIVE CHEMICAL ANALYSIS, 5th Ed.,
- John Wiley & Sons, Inc., New York (1989).
- Sime R.J.: PHYSICAL CHEMISTRY: METHODS, TECHIQUES, AND EXPERIMENTS, Sounders College Publishing (1990).

Course Outcomes:

At the end of this course, students will be able to

1. Identify the rare earth metals from the mixtures.
2. Explain the preparation method of inorganic compounds.
3. Understand the reaction mechanism in the conversion of organic compounds.
4. Demonstrate the potentiometric titration as well as pH analysis.

Course Name: Molecular thermodynamics **Code: CHL-6112**
Credits: 2

Course Objectives:

The objective of this course is to identify the various radicals and insoluble residues from the mixture and understand the various reaction mechanism. Analysis of the quality of water is also the goal of this course.

Course Outcomes:

At the end of this course, students will be able to:

1. Identify various rare earth metals as well as insoluble residues.
2. Explain the preparation of inorganic compounds.
3. Define the reaction mechanism in various reactions.
4. Evaluate the water quality parameters such as pH, BOD, COD etc.
5. Perform the transport number based experiments.

1. Qualitative Analysis of Inorganic Mixture

Identification of 07 radicals including insoluble residue and rare earth metal ions by semi-micro analysis.

(ii) Rare elements: Tl, W, Se, Mo, Ti, Zr, Ce, Th, V, U, Li

(iii) Insoluble Residue: $PbSO_4$, $SrSO_4$, Al_2O_3, Cr_2O_3, Fe_2O_3, SnO_2, AgX, TiO_2, ThO_2, $WO_2.xH_2O$

2. Preaprationi of Inorganic Compounds:

(i) trans-potassium di aqua bis(oxalato) chromate (III)

(ii) cis-potassium di aqua bis(oxalato) chromate (III)

3. Reaction Mechanism

(i) To perform Cannizaro reaction: Benzyl alcohol and benzoic acid from benzaldehyde

(ii) To perform Perkin reaction: Cinnamic acid from benzaldehyde

4. Analysis of water quality parameters: pH, conductance, dissolved oxygen, hardness, chloride and fluoride.

5. Determine the transport number of Ag^+ and NO_{3^-} ions in solution using 0.1 M and 0.01 M $AgNO_3$ solutions (Given: Mean ionic activity coefficients of $AgNO_3$ in 0.01 M and 0.1 M solutions are 0.89 and 0.73, respectively).

SUGGESTED READINGS:

1. Yadav J.B.: ADVANCED PRACTICAL PHYSICAL CHEMISTRY, Krishna Prakashan Media (P) Ltd., Meerut (2016).
2. Jeffery G.H., Bassett J., Mendham J. and Denney R.C.: VOGEL'S TEXTBOOK OF QUANTITATIVE CHEMICAL ANALYSIS, 5th Ed.,
3. John Wiley & Sons, Inc., New York (1989).
4. Sime R.J.: PHYSICAL CHEMISTRY: METHODS, TECHIQUES, AND EXPERIMENTS, Sounders College Publishing (1990).

Semester: II

Course Name: Molecular thermodynamics **Code: CHL-6211**
Credits: 4

Course Objectives:
Thermodynamics which is an important branch of science and deals with the study of heat, work, temperature etc. and their relation to various types of energy and the physical properties of the matter. Their behaviour can be explained by laws of thermodynamics. Therefore, the objective of the study is to explain the concept of thermodynamics, their laws, states as well as path function and ideal and non-ideal solutions.

Block I: Introduction to thermodynamics

Unit 1: Basics concepts, Review of first, second, and third laws of thermodynamics, Gibb's free energy Extra work, Chemical potential, Ideal and non-ideal solution.
Unit 2: Phase rule, Phase diagram, Solutions, Chemical equilibrium.
Unit 3: Postulates of statistical thermodynamics, Ensembles, Monoatomic and polyatomic ideal gases, Molar heat capacities.

Block II: Laws of thermodynamics

Unit 4: Basic concepts (State function, mixed derivative, Equations of gases).
Unit 5: Review of First law of thermodynamics (internal energy, enthalpy, heat capacity, Joule Thomson experiment).
Unit 6: Review of Second and Third law of thermodynamics (entropy change, Clausius inequality, probability, absolute entropy).

Block III: Statistical thermodynamics

Unit 7: Chemical potential, Clausius equation.
Unit 8: Change of chemical potential with Temperature, pressure and addition of solute.
Unit 9: Statistical thermodynamics, ensembles, monoatomic and polyatomic ideal gases, molar heat capacities, Classical statistical mechanics.

Block IV: Chemical and phase equilibrium

Unit 10: Ideal and real gases, properties of fugacity, mixing and excess functions.
Unit 11: Chemical equilibrium, Le Chatelier's principle, partial molar quantities, standard states.
Unit 12: Phase equilibrium involving one, two and three components.

Block V: Equilibrium in condensed phases

Unit 13: Ideal solution and colligative properties, binary solutions and azeotropes.
Unit 14: Non-ideal systems, activity and activity coefficients. Thermodynamic formulation of surface phenomena.
Unit 15: Non-ideal systems, activity and activity coefficients. Thermodynamic formulation of surface phenomena.

Books Recommended/Suggested Reading:

1. *Physical Chemistry: Statistical Mechanics Kindle Editio by Horia Metiu Kindle Edition.*
2. *Physical Chemistry by Peter Atkins , Julio De Paula.*
3. *Physical Chemistry by Arun Bahal, B.S. Bahal.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Explain the general concepts of thermodynamics.
2. Define the laws of thermodynamics.
3. Examine classical statistical mechanism.
4. Summarize Chemical equilibrium and phase Equilibrium.
5. Illustrate equilibrium in condensed phase.

Course Name: Organic Synthesis **Code: CHL-6212**
Credits: 4

Course Objectives:
Organic chemistry is a separate branch in which carbon is the essential elements. The scope of organic chemistry in different fields are also important. Therefore, the objective of this study is to explain the synthesis of organic compounds, their derivative for various reaction mechanism.

Block I: Organic Synthesis
Unit 1: Formation of carbon-carbon bonds including organometallic reactions, Synthetic applications of organoboranes and organ silanes.
Unit 2: Reactions at inactivated C-H bonds, Oxidations, Reductions, Newer Reagents, Design of organic synthesis.
Unit 3: Retrosynthetic analysis, Selectivity in organic synthesis, Protection and deprotection of functional groups, Multistep synthesis of some representative molecules.

Block II: Synthetic equivalents
Unit 4: Strategy and design of organic synthesis: Introduction, scope and a brief history of organic synthesis, synthetic strategy, retro-synthesis, analysis and practice of total synthesis, linear and convergent synthesis.
Unit 5: Concepts of synthetic equivalents and Umpolung: benzoyl and acyl anion equivalents, dithianes, enol ethers and nitro compounds.
Unit 6: Carbon-Carbon bond formation: alkylation of enolates, enamines and hydra zones, alkylation of heteroatom stabilized anions, organometallic reagents.

Block III: Carbon-Carbon double bond formation
Unit 7: Carbon-Carbon double bond formation: aldol condensation, Wittig and related reactions.
Unit 8: Peterson olefination, Julia-Lythgoe olefination, carbonyl coupling reaction (McMurry reaction).
Unit 9: Tebbe reagent, Shapiro and related reactions

Block IV: Cross coupling reaction and Carbon-Carbon triple bond formations
Unit 10: Elimination and dehydration, from diols and epoxides, from acetylenes, from other alkenes (olefin metathesis and transition metal catalysed cross coupling reactions).
Unit 11: Carbon-Carbon triple bond formations: from other acetylenes, from carbonyls,
Unit 12: Carbon-Carbon triple bond formations from olefins, from strained rings, Eschenmoser fragmentation, allenes etc.

Block V: Ring Compounds
Unit 13: 3-Membered rings: Epoxides- using peracids, hydroperoxides and dioxiranes; transition metal catalysed epoxidation, halohydrins, Darzen's condensation, sulphur ylides, Cyclopropanes-

Simmons Smith reaction, diazo compounds, sulphur ylides and SN2 displacements. Aziridines-nitrenes and SN2 displacements.

Unit 14: 4-Membered rings: Various methods of forming cyclobutanes, cyclobutene's and oxetanes

Unit 15: 5-Membered rings: intramolecular SN2 reactions, intramolecular Michael and aldol condensation reactions, intramolecular Wittig olefination, ring expansion and contraction reactions, 1,3-dipolar cycloaddition reactions.

Books Recommended/Suggested Reading:

1. *David J. Hart "Organic Synthesis via Examination of Selected Natural Products" World Scientific.*
2. *S. Warren, "Designing Organic Syntheses", John Wiley & Sons.*
3. *"Modern Organic Synthesis-An Introduction", G. S. Zweifel and M. H. NantzW. H. Freeman and Company, 2006.*
4. *"Principles of Organic Synthesis", R. O. C. Norman and J. M. Coxon.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Examine the organic synthetic analysis.
2. Outline synthetic equivalents.
3. Interpret Carbon-Carbon double bond formation.
4. Illustrate Cross coupling reaction and Carbon-Carbon triple bond formations.
5. Explain the ring compounds.

Course Name: Transition and Inner Transition Metal Chemistry **Code: CHL-6213** **Credit: 4**

Course Objectives:

Transition elements which are also known as d-block elements are important constituents in co-ordination chemistry. Their binding with strong and weak filed ligands, tendency to form complexes and related theory etc. are some important concepts which are explained in this course. The objective of this unit is to explain the properties of transition metals in terms of formation of octahedral, square planar complex and various theory related to the coordination chemistry.

Block I: Coordination chemistry: General Introduction

Unit 1: Introduction to coordination chemistry, Crystal field theory

Unit 2: Ligand field theory, Molecular orbital theory

Unit 3: Magnetic and spectral characteristics of inner transition metal complexes, Substitution.

Block II: Electron transfer reaction

Unit 4: Electron transfer and photochemical reactions of transition metal complexes.

Unit 5: Physical, spectroscopic properties of transition metal complexes

Unit 6: Electrochemical methods used in the study of transition metal complexes.

Block III: Metal-Metal bonded compounds and Bioinorganic chemistry

Unit 7: Metal-metal bonded compounds and transition metal cluster compounds.

Unit 8: Uses of lanthanide complexes: as shift reagents, as strong magnets, and in fluorescence,

Unit 9: Bioinorganic chemistry: introduction, Bioinorganic chemistry of iron: haemoglobin, myoglobin, cytochromes, Bioinorganic chemistry of zinc, cobalt, and copper.

Block IV: Transition elements

Unit 10: Introductory survey of transition elements with reference to electronic configuration, oxidation states, complex compounds.

Unit 11: Introductory concepts of molecular symmetry.

Unit 12: Spectral and magnetic properties.

Block V: Chemistry of some elements

Unit 13: Introduction to theories of metal-ligand bonding and stereochemistry.

Unit 14: Chemistry of titanium, vanadium, chromium, manganese sub-group elements, group III, IV, V, VI, VII and rare gases with reference to isolation, properties, uses and important compounds.

Unit 15: Chemistry of Iron, cobalt, nickel, platinum metals, copper and zinc sub-group elements, group III, IV, V, VI, VII and rare gases with reference to isolation, properties, uses and important compounds.

Books Recommended/Suggested Reading:

1. *Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson, Wiley Easter.*
2. *Inorganic Chemistry, R.A. Plane.*
3. *Chemical Principles and Properties, McGraw Hill, J. D. Lee, Concise, Van Nostrand Reinhold.*
4. *Organometallics and catalysis An introduction. Bochmann, M, 1st edn, Oxford, 2014.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Explain general introduction of coordination chemistry.
2. Define electron transfer reactions.
3. Interpret metal-metal bonding and bioinorganic compounds.
4. Illustrate transition elements.
5. Evaluate the chemistry of some elements.

Course Name: Basic Organometallic Chemistry **Code: CHL-6214**

Credits: 4

Course Objectives:

The objective of this course is to understand the compounds and reactions involving metal-carbon bonds. To explain the structure of organometallic compounds, role of electron donor as well acceptor, applications of organometallic compounds and the concept of hapticity is also the goal of this research.

Block I: metal-carbon bond

Unit 1: Introduction; factors guiding metal-carbon bond formation; general synthetic methods for Main Group organometallics

Unit 2: Structure and bonding of alkali, alkaline-earth organometallics. EAN rule.

Unit 3: Classification of carbon-based ligands by donor atoms and no of electrons donated by the ligand, sigma-donor and pi-acceptor-; transition metal organometallics; reactivity studies.

Block II: Organometallic compounds as homogeneous catalysis

Unit 4: Applications of organometallic compounds in homogenous catalysis; hydrogenation, carbonylation, metal-mediated C-X (X = C, heteroatom) bond formations.
Unit 5: Olefin metathesis and Ziegler-Natta polymerization
Unit 6: Stereochemistry, applications in asymmetric synthesis.

Block III: Organometallic chemistry of main group elements
Unit 7: Organometallic chemistry of main group, transition and inner transition metals.
Unit 8: Synthesis and applications of Buli, Grignard, organo aluminum and organozinc reagents.
Unit 9: 18 electron rule.

Block IV: Metal Carbonyls
Unit 10: Metal carbonyls- bonding and infrared spectra, phosphines and NHC's.
Unit 11: Alkenes and alkynes, carbenes and carbines, Hapto ligands with hapticity from 2- 8.
Unit 12: Oxidative addition and reductive elimination, 1,1 and 1,2-migratory insertions and beta hydrogen elimination, mechanism of substitution reactions.

Block V: Organometallic cluster and cross coupling reactions
Unit 13: Fluxionality and hapticity change, organometallic clusters, C-H activationagostic and anagostic interactions.
Unit 14: Homogeneous catalysis: hydrogenation, hydroformylation, methanol to acetic acid processes, Wacker oxidation.
Unit 15: Introduction to cross coupling and olefin metathesis reactions. Olefin oligomerization and polymerization.

Books Recommended/Suggested Reading:

1. *G. O. Spessard, G. L. Miessler, Organometallic Chemistry, Prentice Hall*
2. *F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, Advanced Inorganic Chemistry*
3. *The organometallic chemistry of the transition metals, Crabtree R H*
4. *Gupta, B.D, Elias, A J; Basic Organometallic Chemistry, Concepts, syntheses and applications, 2nd edn, Universities Press, 2013.*
5. *Organometallics, Elschenbroich, Ch, 3rd edn, Wiley VCH, 1989.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Define metal-carbon bond.
2. Explain organometallic compounds as homogeneous catalysis.
3. Interpret Organometallic chemistry of main group elements.
4. Understand metal carbonyls.
5. Illustrate Organometallic cluster and cross coupling reactions

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Semester II: Program Elective

Course Name: Supramolecular Chemistry **Code: CHL-6221**
Credits: 3

Course Objectives:
The objective of this study is to explain the host-guest interaction, reactivity and physical method used for the determination of supramolecular chemistry.

Block I: Host-guest Chemistry

Unit I: Host-Guest Chemistry: Definition, classifications of host guest compounds.

Unit 2: Hydrodynamics and kinetic stability, role of weak interactions in supramolecules, Complementarity and cooperativity.

Unit 3: Hydride sponge and related clathrates. Different macromolecular hosts: host design, preorganised hosts, cyclodextrins, calixarenes, cucurbiturils etc.

Block II: Recognition and reactivity

Unit 4: Recognition and reactivity: molecular and Ion recognition, enatioselectivity, proton pumps and basis of supramolecular catalysis.

Unit 5: Inorganic host design: Metal directed assemblies, confinement, container molecules.

Unit 6: Molecular flasks, layered solids, channel structures, Intra-cavity complexes of neutral molecules.

Block III: Physical Methods

Unit 7: Physical methods in understanding supramolecular chemistry: Determination of binding constant.

Unit 8: Isothermal titration calorimetry.

Unit 9: Rheology, SEM, TEM etc.

Block IV: Supramolecular polymers and gel

Unit 10: Co-ordination polymers, hydrogen bond-based polymers, guest included polymers examples and applications.

Unit 11: Supramolecular gels: hydrogel and organogel and their applications.

Unit 12: Transient gels, and their applications.

Block V: Molecular machines

Unit 13: Molecular machines: interlocked dynamic systems, molecular motors, switch, and shuttles.

Unit 14: Amphiphiles and their self-aggregation: micelle, vesicles, liposomes, microemulsions.

Unit 15: H and J aggregates, aggregation induced emission and quenching. Natural processes: Peptide self-assembly, Protein and DNA aggregation, amyloid and cell membrane.

Books Recommended/Suggested Reading:

1. Core Concepts in Supramolecular Chemistry and Nanochemistry, J. W. Steed, D. R. Turner, K. Wallace, 1st Edition, Wiley, 2007.
2. Supramolecular Chemistry: Concepts and Perspectives, J. M. Lehn, 1st Edition, VCH, 1995.
3. H. Dodziuk, Introduction to Supramolecular Chemistry, 1st Edition, Springer, 2001.
4. Supramolecular Chemistry: Fundamentals and Applications, Katsuhiko, 1st Edition Springer, 2006.

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Define host-guest chemistry.
2. Explain Recognition and reactivity.
3. Interpret physical methods.
4. Illustrate supramolecular polymers and gel.
5. Understand molecular machines.

Course Name: Chemistry Lab-III **Code: CHL-6211**
Credits: 2

Course Objectives:

The objective of the course is to understand standard method used for the analysis of elements. To understand the preparation of inorganic compounds, physical analysis and estimation of various ions present in the water sample is also discussed in this course.

1. Inorganic analysis

(i) Estimation of chromium using certified standard materials colorimetrically.

(ii) Morphological analysis of metal oxides nano particles by Scanning Electron Microscopy.

2. Preparation of some inorganic Compounds

(i) Potassium tri oxalato ferrate (III) trihrdrate.

(ii) Sodium hexa nitrito cobaltate (III)

3. Organic Analysis

(i) Separation of organic compounds (phenol, catechol, resorcinol and pyrogallol) using TLC method

(ii) Paper chromatographic separation of Cu^{2+} and Cd^{2+}

4. Physical Analysis

(i) Determine the activity coefficient of Ag^{+} ions in $AgNO_3$ solution, potentiometrically, using a concentration cell with a salt bridge.

(ii) Study spectrophotometrically the kinetics of the reaction between potassium per sulphate and potassium iodide and determine the order and rate constant of the reaction.

(iii) A kinetic study of a solvolysis reaction-solvolysis of t-butyl chloride in acetone-water mixture.

5. Environmental Analysis

(i) Analysis of major anions (F, Cl, NO_3, SO_4) and major cations (Na, Ca, K, Mg, NH_4) in water by ion-exchange chromatography.

(ii) Determination of Cu/ Cd/Fe in water samples by Atomic Absorption Spectrophotometer.

SUGGESTED READINGS:

- Khosla B.D., Gulati A. and Garg V.C.: SENIOR PRACTICAL CHEMISTRY, R. Chand & Co., (2008).
- Shoemaker D.P., Garland C.W. and Nibler J.W.: EXPERIMENTS IN PHYSICAL CHEMISTRY, McGraw Hill, New York (1996).
- Yadav J.B.: ADVANCED PRACTICAL PHYSICAL CHEMISTRY, Goel Publishing House (2000).
- Lewitt B.P.: FINDLEY'S PRACTICAL PHYSICAL CHEMISTRY, Longman (1990).
- Furniss B.S., Hannaford A.J., Smith P.W.G. and Tatchell A.R.: VOGEL: PRACTICAL ORGANIC CHEMISTRY, (1989).

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Evaluate the morphology and amount of metal ions in the given msample.
2. Explain general preparation method of inorganic compounds.
3. Interpret organic analysis
4. Illustrate physical analysis.
5. Define environmental analysis.

Course Name: Chemistry Lab-IV **Code: CHL-6212**

Credits: 2

Course Objectives:

The objective of the course is to explain the qualitative mixture analysis and topological analysis using AFM. The determination of rate constant, water quality parameters and pesticides determination in water sample is also the objective of this study.

1. Inorganic Analysis

(i) Semi-micro qualitative mixture analysis including less common metal ions, such as, TI, Mo, W, Ti, Zr, Th, V and U (two metal ions in cationic/anionic forms).

(ii) Topological analysis of nanostructured metal oxides using Atomic Force Microscope

2. Organic Analysis

(i) To perform Aldol condensation: Dibenzal acetone from Benzaldehyde
(ii) To perform Reduction: 1-amino-2-hydroxynaphthalene hydrochloride from phenylazo-2-naphthol
(iii) Isolation and chromatographic separation of lycopene from tomatoes.
(iv) Green synthesis of p- bromo acetanilide.

3. Physical Analysis

(i) Determination of pKa of an indicator (methyl red) in aqueous media

(ii) Determination of rate constant for hydrolysis/inversion of sugar using polarimeter

(iii) Determine the equilibrium constant of the reaction $Ag(NH)_2^+ \leftrightarrow Ag^+ + 2NH_3$ potentiometrically.

4. Environmental Analysis

(i) Analysis of water quality parameters: pH, conductance, dissolved oxygen, hardness, chloride and fluoride.

(ii) Determination of Pesticides by Gas chromatography in drinking water samples.

(iii) Analysis of SO_2, NH_3, NO_2 and O_3 with real time value from online analyzers.

SUGGESTED BOOKS

- Burns D.T. and Rattenbury E.M.: INTRODUCTORY PRACTICAL PHYSICAL CHEMISTRY, Pergamon Press (1966).
- Daniels F., Williams J.W., Bender P., Alberty R.A., Cornwell C.D. and Harriman J.E.: EXPERIMENTAL PHYSICAL CHEMISTRY, McGraw Hill (1962).
- Day R.A. and Underwood A.L.: QUANTITATIVE ANALYSIS, Prentice Hall India Pvt. Ltd., New Delhi, 3rd Ed., (199
- EwingG.W.: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS, McGraw Hills (1989).
- Yadav J.B.: ADVANCED PRACTICAL PHYSICAL CHEMISTRY, Goel Publishing House (2000).

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Evaluate the topology and qualitative analysis of some elements.
2. Explain organic analysis.
3. Interpret physical analysis
4. Define environmental analysis.

Semester: III

Course Name: Bioinorganic and Biophysical Chemistry **Code: CHL-7111**
Credits: 4

Course Objectives:
The bioinorganic elements play an important role in the biological systems. Therefore, the object of this course is to explain the role of essential metal ions, metalloenzymes, biopolymer and biomolecular simulation in biological systems.

Block I: Essential and trace metal ions
Unit 1: Essential and trace metal ions in biological system.
Unit 2: Deficiency/excess of Mn, Co, and Zn metal ions.
Unit 3: Structure of chlorophyll, Photosynthesis, Photo system I and Photo system II.

Block II: Metalloenzymes
Unit 4: Cytochromes and iron-sulphur proteins, nitrogen fixation.
Unit 5: Zinc enzymes; carboxypeptidase, carbonic anhydrase.
Unit 6: Iron enzymes-catalase and peroxidase. Copper enzyme –superoxide dismutase. Cobalt enzyme; cyanocobalamin.

Block III: Biopolymer interactions and Thermodynamics of Macromolecular solutions
Unit 7: Non-covalent interaction, Electrostatic: dipole-dipole interaction, Dispersion force interaction, Hydrophobic interaction.
Unit 8: Multiple Equilibria and various types of binding processes in biological systems. Thermodynamics of biopolymer solutions.
Unit 9: Flory-Huggins model of macromolecular solvation, Osmotic pressure and Donnean membrane equilibriums.

Block IV: Statistical Mechanics and Biomolecular simulations
Unit 10: Chain configuration of macromolecule, Random walk model.
Unit 11: statistical distribution of end to end dimension.
Unit 12: Calculation of average dimension of various chain structures.

Block V: Conformational transitions
Unit 13: Helix-coil transition, Protein folding problem.
Unit 14: Molecular mechanics and dynamics: Basic principles – molecular representations – force fields – atom-atom pair potentials – bond length and bond angle and torsion angle potential
Unit 15: Van der Waals and electrostatic potential concepts of molecular dynamics – introduction to time-step integration algorithms and force fields.

Books Recommended/Suggested Reading:

1. *Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.*
2. *Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.*
3. *Inorganic Biochemistry, vols I and II. ed., G.L. Eichhorn, Elsevier.*
4. *Progress in Inorganic Chemistry, Vols. 18 and 38 ed. J.J. Lippard, Wiley*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Define essential and trace metal ions.
2. Outline Metalloenzymes.
3. Interpret Biopolymer interactions and Thermodynamics of Macromolecular solutions.
4. Explain Statistical Mechanics and Biomolecular simulations.
5. Interpret conformational transitions

Course Name: Analytical Techniques **Code: CHL-7112**
Credits: 4

Course Objectives:
Spectroscopy is that branch of chemistry that deals with the interaction of electromagnetic radiations with matter. Different spectroscopy is used for different purposes. Therefore, the objective of the course is to explain the basic concept of electron spectroscopy, microscopy and particle size determination method.

Block I: Electron spectroscopy
Unit 1: Electron Spectroscopy Definition of a solid surface, Types of surface measurements;
Unit 2: X-Ray photoelectron spectroscopy (XPS/ESCA): Introduction, principle, chemical shifts as a function of oxidation states, instrumentation, applications;
Unit 3: Auger electron spectroscopy: principle, instrumentation- radiation source, energy analyser, detector, auxiliary system; applications- quantitative analysis.

Block II: Electron Microscopy
Unit 4: Scanning electron microscopy (SEM): basics, instrumentation, applications.
Unit 5: Transmission electron microscopy (TEM): Introduction, Basic theory, Electron gun, Electromagnetic lenses, Imaging, Operating parameters- magnification, resolution, depth of field.
Unit 6: Sample preparation, Specimen orientation and manipulation; Applications; Selected Area Electron Diffraction.

Block III: Particle Size Determination
Unit 7: Introduction to Particle Size Analysis, Selection criteria for choosing appropriate analytical techniques.
Unit 8: Low Angle Laser Light Scattering (LALLS): Instrumentation, Theoretical models, Particle size distribution analysis, Applications.
Unit 9: Dynamic Light Scattering (DLS): Principles, Instrumentation - sample cell & its handling, photodetector.

Block IV: Automations
Unit 10: Photo sedimentation: Setting velocity & particle size, The Stokes equations, Instrumentation, Applications.
Unit 11: Automated Methods of Analysis Principles of automation
Unit 12: Advantages and disadvantages of automatic analysis.

Block V: Unit Operation
Unit 13: operations in chemical analysis, Process control, Types of automatic analytical systems
Unit 14: Flow Injection Analysis (FIA)- principles, instrumentation- sample and reagent transport system, sample injectors and detectors

Unit 15: Sequential injection analysis; Applications.

Books Recommended/Suggested Reading:

1. *Instrumental Analysis, 2nd Ed., Bauer, Christian, O'Reilly, Allyn and Bacon.*
2. *Instrumental Methods of Analysis, 7th Ed., Willard, Merritt, Dean and Settle, CBS Publishers.*
3. *Principles of Instrumental Analysis, 5th Ed- Indian Reprint, Skoog, Holler, Nieman, Harcourt Asia.*
4. *Instrumental Analysis, 1/e, Skoog, Holler, Crouch, Brooks Cole- Cenage Learning*
5. *Analytical Chemistry, 6th Ed., G.D. Christian, John Wiley & Sons (Asia) Pte. Ltd, New Delhi*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Explain electron spectroscopy.
2. Define electron microscopy.
3. Evaluate particle size.
4. Illustrate automations
5. Choose unit operation

Course Name: Organic Photochemistry **Code: CHL-7113**

Credits: 4

Course Objectives:

Organic photochemistry is special branch of chemistry that involves organic reaction induced by the action of light. The action of light causes several reactions such as absorption, emission, fluorescence, phosphorescence etc. Therefore, the objective of this course is to explain the photochemistry of organic molecules and corresponding reactions as well as rearrangements.

Block I: Fundamentals of photochemistry

Unit 1: Absorption of light by molecules: direct and indirect excitation, electronically excited states, types of excitation, and laws of photochemistry.

Unit 2: Properties of excited states: decay of electronically excited states, spin allowed and spin forbidden transitions.

Unit 3: Photophysical processes: radiative (fluorescence, phosphorescence), nonradiative (state-to-state crossing, vibrational relaxation), combination of radiative and non-radiative processes, Jablonski diagram.

Block II: Photochemistry of excited state and carbonyl compounds

Unit 4: Transfer of excitation energy photosensitization and quenching. Excited-state complex formation: excimer and exciplex. Photoinduced electron transfer: homogeneous and heterogeneous photoelectron transfer reactions.

Unit 5: Photochemistry of Carbonyl Compounds: Intramolecular reactions of carbonyl compounds: saturated, cyclic and acyclic, β, λ- Unsaturated and α, β- unsaturated compounds, and Cyclohexadienone.

Unit 6: Intramolecular cycloaddition reactions-dimerization's and oxetane formation.

Block III: photochemistry of aromatic compounds

Unit 7: Photochemistry of Aromatic Compounds: Photoinduced isomerisations of benzene and its alkyl derivatives.

Unit 8: 1, 2; 1, 3 and 1, 4-photocycloaddition reactions of benzene.
Unit 9: Nucleophilic photosubstitution reactions in aromatic compounds.

Block IV: Miscellaneous Reactions
Unit 10: Barton reaction
Unit 11: Hoffmann-Loeffler-Freytag reaction.
Unit 12: Singlet molecular oxygen reactions. Photo-Bergman cyclisation.

Block V: Rearrangement reactions
Unit 13: Photo-Fries rearrangement.
Unit 14: Photochemical Nazarov cyclisation. Photo-Favorskii rearrangement.
Unit 15: Bicycle rearrangement. Photochemical Wolff rearrangement.

Books Recommended/Suggested Reading:

1. *Fundamental of Photochemistry, K.K.Rohtagi- Mukherji, Wily- Eastern.*
2. *Essentials of Molecular Photochemistry, A.Gilbert and J.Baggott, Blackwell Scientific Publication.*
3. *Molecular Photochemistry, N.J. Turro, W.A. Benjamin.*
4. *Introductory Photochemistry, A. Cox and T. CAMP, Mc Graw-Hill.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Analyze Fundamental Principles of Photochemistry.
2. Examine Photochemistry of excited state and Carbonyl Compounds.
3. Explain Photochemistry of Aromatic Compounds.
4. Evaluate Miscellaneous Photochemical Reactions.
5. Interpret rearrangement reactions.

Semester III: Program Elective

Course Name: Solid State Chemistry **Code: CHL-7121**
Credits: 3

Course Objectives:
Solid is one of the most fundamental units of matter. The constituents particles in solids are closed packed together and form a complete unit cell. The arrangement of atoms in unit cell, and their diffraction through various crystal lattice planes are also discussed in this course. Therefore, the objective of this course is to study the arrangement of atoms in unit cell, presence of impurities which creates several defect and the synthesis of novel materials as well as identification and chemical composition of the molecule.

Block I: Solid state

Unit 1: Types of solids, isomorphism and polymorphism, laws of crystallography, lattice types.
Unit 2: X-ray diffraction, Bragg's equation, Miller indices.
Unit 3: Bragg Method, Debye-Sherrer method of X-ray structure analysis of crystals.

Block II: Structure Factor

Unit 4: Indexing of reflections, identification of unit cells from systematic absence in diffraction pattern.
Unit 5: Structure of simple lattice and X-Ray intensities.
Unit 6: Structure factor and its relation to intensity and electron density, phase problem, procedure for an X-ray structure determination.

Block III: Solid state reactions
Unit 7: General principle, types of reactions: Additive, structure sensitive, decomposition and phase transition reactions.
Unit 8: Tarnish reactions, kinetics of solid state reactions.
Unit 9: factors affecting the reactivity of solid state reactions.

Block IV: Electronic Properties and Band Theory
Unit 10: Metals, insulators and semi-conductors, free electron theory and its applications.
Unit 11: Electronic structure of solids, band theory, band structure of metals, insulator, and semiconductors, doping in semiconductors.
Unit 12: p- n junction, super conductors, optical properties, photoconduction and photoelectric effects.

Block V: Preparation method
Unit 13: laser action, solid state laser and their applications, Preparation of materials: Purification and crystal growth
Unit 14: Zone refining, growth from solution, growth from melt
Unit 15: Preparation of organic semiconductors for device applications.

Books Recommended/Suggested Reading:
1. Principals of solid state, H. V. Keer, Wiley Eastern.
2. Solid state chemistry, N. B. Hannay.
3. Solid state chemistry , D. K. Chakrabarty , New Age International.
4. An Introduction to Crystallography : F. G. Philips.
5. Crystal Structure Analysis: M. J. Buerger.
6. Electronic processes in materials : L. U. Azroff and J. J. Brophy.
7. Chemistry of imperfect crystal : F. A. Krogen.

Course Outcomes:
On successful completion of this course, students shall be able to:
1. Explain solid state.
2. Interpret structure factor.
3. Define solid state reactions.
4. Evaluate electronic properties and band theory.
5. Analyse preparation methods.

Course Name: Project **Code: CHD-7211**
Credits: 4

Course Objectives: The objective of the course is to work with students to identify mathematical problem. The course also focuses to find out probable solution of that mathematical problem.

Syllabus

Every student shall, in the Fourth (final) Semester, submit a Dissertation reporting the results of original research on a topic assigned at the beginning of the semester by the concerned research guide (faculty member) in consultation with the student, in his/her area(s) of special interest. The research guide shall be chosen by the student according to his/her interest and the faculty member's area of expertise. No faculty member shall guide more than five students.

The topic of the Dissertation shall be approved by the Head of the Department. For this purpose the candidate shall submit to the Head an application stating the topic for the dissertation along with a synopsis within three weeks of the commencement of classes of the Fourth Semester. Once approved, the topic of dissertation shall not be altered without a fresh proposal from the student accompanied by a written request stating the reason for change. No such request shall be entertained after five weeks of the commencement of classes of the Semester in question.

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Identify and Define appropriate research problems.
2. Explain appropriate research approaches for solving problems.
3. Apply various tools and techniques to complete research.
4. Analyse research report and make robust conclusion.

Semester: IV

Course Name: Inorganic polymers **Code: CHL-7211**
Credits: 4

Course Objectives:

Polymers are the substances made up of large number of molecules called the macromolecules and are the important constituents of many materials. On the other hand inorganic polymers also made up of large number of molecules but does not include carbon atoms in the backbone. The detailed study of inorganic polymers, their classification, structure, and advanced applications are the objectives of this course.

Block I: Inorganic polymer: Introduction

Unit 1: Introduction, Properties and classification of Inorganic Polymers.
Unit 2: Phosphorous, Sulphur, Boren and Silicon based polymers.
Unit 3: Polyphosphazenes, polycarboanes, polyboron.

Block II: Coordination Polymers

Unit 4: Nitride and silicones.
Unit 5: Natural, Chain polymers
Unit 6: 2D and 3D coordination polymers.

Block III: Polymer reaction and mechanism

Unit 7: Isopoly and heteropoly acids and anions.
Unit 8: Polymerization of chromate, and vanadates, Keggin structure.
Unit 9: Reactions of iso and heteropoly anions.

Block IV: Inorganic polymers in nanotechnology

Unit 10: Basic, nanotechnology science and chemistry concepts.
Unit 11: Basic Inorganic nanostructures
Unit 12: Nano composites, thin films, nano foam.

Block V: Advanced Inorganic Materials
Unit 13: Nanotechnology and its industrial applications.
Unit 14: Introduction to nano scale
Unit 15: Potential applications of Inorganic nano materials.

Books Recommended/Suggested Reading:

1. *Fundamentals of Inorganic Chemistry by Puri-Sharma and Kalia*
2. *Inorganic Chemistry by Cotton & Wilkinsen*
3. *Teraoka, Polymer Solutions: An Introduction to Physical Properties, John Wiley & Sons, 2002.*
4. *J.E. Mark, H.R. Allcock, R. West, Inorganic Polymers, 2nd Edn., Oxford University Press, 2005.*
5. *V. Chandrasekhar, Inorganic and Organometallic Polymers, Springer, 2005.*

Course Outcomes:
On successful completion of this course, students shall be able to:

1. Define Inorganic Polymers.
2. Explain coordination polymer.
3. Summarize polymer reaction and mechanism.
4. Interpret Inorganic polymers in nanotechnology.
5. Understand Advanced Inorganic Materials

Semester IV: Program Elective

Course Name: Statistical Thermodynamics **Code: CHL-7221**
Credits: 3

Course Objectives:
The properties of the bulk material can be studied with the help of statistical thermodynamics. Therefore, the objective of this course is to explain the properties of the microscopic particles and the behaviour of bulk materials. The mechanics and equilibrium, thermodynamic functions and different types of ensembles as well as distribution is another important topics which are covered in this course.

Block I: Statistical thermodynamics: Introduction
Unit 1: Systems of Independent Particles Concept of a distribution, number of wave functions for a distribution: for Fermi-Dirac and Bose Einstein cases.
Unit 2: Distinguishable particles, corrected Bolton's, fundamental distribution law, parameters α and β, perfect gas and β.
Unit 3: Statistical expression for heat change, heat change statistical mechanical entropy.

Block II: Thermodynamic functions
Unit 4: Thermodynamic functions for a system of corrected Bolton's, comments on the Boltzmann distribution and corrected Boltzmann statistics,
Unit 5: Fermi-Dirac and Bose-Einstein statistics.
Unit 6: Conditions for the applicability of Boltzmann statistics.

Block III: Statistical Mechanics and Chemical equilibrium

Unit 7: Statistical Mechanics and Chemical Equilibrium, Equilibrium constant in terms of partition functions.

Unit 8: Change in the zero of energy, partition functions for translational and internal degrees of freedom, free energy and q/N for different standard states.

Unit 9: Distribution laws, Partition Functions and Thermodynamic Functions for Atoms and Diatomic molecules.

Block IV: Canonical Ensembles

Unit 10: Canonical and Grand Canonical Ensembles Canonical ensemble and ensemble average.

Unit 11: Perfect gas in canonical ensemble, entropy and free energy, grand canonical ensemble.

Unit 12: Entropy and other thermodynamic functions in grand canonical ensemble.

Block V: Fluctuations in ensemble

Unit 13: Fluctuations Mean of the distribution and the mean-square deviation, fluctuation in energy in a canonical ensemble.

Unit 14: density fluctuations in grand ensemble: one component systems, energy fluctuations in grand ensemble.

Unit 15: Real Gases Virial Expansions, configuration Integral and the canonical partition function, the second virial coefficient.

Books Recommended/Suggested Reading:

1. *Norman Davidson, Statistical Mechanics, McGraw-Hill, New York.*
2. *R.P.H. Gasser and W.G. Richards, Introduction of Statistical Thermodynamics, World Scientific.*
3. *T.L. Hill, An Introduction to Statistical Thermodynamics, Dover, New York.*
4. *Elements of statistical thermodynamics - L. K. Nash, Addison Wesley.*
5. *Statistical thermodynamics by B. J. McCelland, Chapman and Hall.*
6. *An Introduction to Statistical Thermodynamics by T. L. Hall Addison - Wesley.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Explain general introduction of statistical thermodynamics.
2. Define thermodynamic functions.
3. Summarize Statistical Mechanics and Chemical equilibrium.
4. Understand Canonical Ensembles.
5. Interpret Fluctuations in ensemble

Semester IV: Program Elective

Course Name: Chemistry of Natural Products **Code: CHL-7222**

Credits: 3

Course Objectives:

Natural products are mostly present in the nature and produced by a living organism. The chemistry of natural products is mainly focused on the study of small organic molecules, especially secondary metabolites, produced by natural organism such as bacteria, fungi and plants. The detailed study of isoprene, steroids, alkoxides and their derivatives are the objective of this course.

Block I: Terpenoids

Unit 1: Structure and synthesis of abietic acid.

Unit 2: zingiberene, santonin.

Unit 3: Cuparenonne and caryophyllene.

Block II: Alkaloids

Unit 4: Structure, stereochemistry, synthesis.

Unit 5: Biosynthesis of the following Structure of morphine, reserpine

Unit 6: Ephedrine, (+) Conin.

Block III: Steroids

Unit 7: Occurrence, nomenclature, basic skeleton.

Unit 8: Diels hydrocarbon and study of the following hormones, Androsterone, Testosterone, Estrone, Progesterone.

Unit 9: Aldosterone and cartisone. Biosynthesis of steroids.

Block IV: Prostaglandins

Unit 10: Occurrence, nomenclature, classification.

Unit 11: Biogenesis and physiological effects

Unit 12: Synthesis of PGE2 and PGF2.

Block V: Biogenesis

Unit 13: Alkaloids (pyridine, morphine and indole type) terpenoids of classes with examples, cholesterol, flavones, coumarins, carbohydrates and proteins.

Unit 14: Vitamins: Synthesis and structure of biotin and vitamin B2, synthesis of vitamin B1.

Unit 15: Biological functions of B6, B12, folic acid and thiamin.

Books Recommended/Suggested Reading:

1. *Apsimon: The total synthesis of natural products.*
2. *A.A. Newmen: Chemistry of Terpenes.*
3. *P. D B.Mayo: The chemistry of natural products.*
4. *T.W. Goddwin: Aspects of terpenoid chemistry and biochemistry.*
5. *Woguer: Vitamins and Co enzymes.*
6. *I. Finar: Organic chemistry Vol. II and I.*
7. *J.B. Hendrickson, The molecules of nature.*

Course Outcomes:

On successful completion of this course, students shall be able to:

1. Define terpenoids.
2. Explain alkaloids.
3. Understand steroids.
4. Analyse prostaglandins.
5. Interpret biogenesis

Course Name: Project **Code: CHD-7211**

Credits: 4

Course Objectives:

The objective of the course is to work with students to identify mathematical problem. The course also focuses to find out probable solution of that mathematical problem.

Syllabus

Every student shall, in the Fourth (final) Semester, submit a Dissertation reporting the results of original research on a topic assigned at the beginning of the semester by the concerned research guide (faculty member) in consultation with the student, in his/her area(s) of special interest. The research guide shall be chosen by the student according to his/her interest and the faculty member's area of expertise. No faculty member shall guide more than five students.

The topic of the Dissertation shall be approved by the Head of the Department. For this purpose the candidate shall submit to the Head an application stating the topic for the dissertation along with a synopsis within three weeks of the commencement of classes of the Fourth Semester. Once approved, the topic of dissertation shall not be altered without a fresh proposal from the student accompanied by a written request stating the reason for change. No such request shall be entertained after five weeks of the commencement of classes of the Semester in question.

Course Outcomes:

On successful completion of this course, students shall be able to:

5. Identify and Define appropriate research problems.
6. Explain appropriate research approaches for solving problems.
7. Apply various tools and techniques to complete research.
8. Analyse research report and make robust conclusion.

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Faculty and Support Staff

The University has identified the requisite faculty and support staff as mandated by UGC and formally they shall be allocated the required positions from amongst the existing faculty exclusively for ODL mode or fresh appointments as required so, shall be initiated for which Letter of Intent have been issued to the prospective faculty and staff. The course material prepared by this university will be on par with any open university/Distance education centre in the country.

List of Faculty associated with MSc- Chemistry program is as follows:-

S. No.	Name of Faculty	Designation	Nature of Appointment	Qualification	Subject
1	Prof. Ravi Kant	Professor	Full Time	Ph.D	Chemistry
2	Dr. Monika Singh	Associate Professor	Full Time	Ph.D	Chemistry

Delivery Mechanism

The ODL of MU follows a modern ICT (Information & Communication Technology) enabled approach for instruction. The methodology of instruction in ODL of MU is different from that of the conventional/regular programs. Our ODL system is more learner-oriented and the learner is an active participant in the teaching-learning process. ODL of MU academic delivery system comprises:

A. Print Material
The printed material of the programme supplied to the students will be unit wise for every course.

B. Counselling Sessions
Normally, counselling sessions are held as per a schedule drawn beforehand by the Subject Coordinator. There will be 6 counselling/ contact classes for 4 credit course will be held on the campus on Saturday and on Sunday of 2 hour duration for each course in face to face mode (In case of 2 credit course contact hours are required 6 hours and in case of 6 credit course contact hours required 18 hours). Contact classes will be held in the campus on Saturdays and on Sundays.

C. Medium of Instruction

Medium of Course Instruction: English
Medium of Examination: English

Student Support Systems
Universities Study Centres or Learner Support Centre shall be headed by a coordinator, not below the rank of Assistant professor and shall be augmented with academic and non-academic staff depending on the learner.
The university has made appropriate arrangements for various support services including counselling schedule and resource-oriented services evaluation methods and dates both online and offline modes for easy and smooth services to the students of distance mode.

At present the university have only one study centre on the campus. The institution is not promoting any study centres outside the campus. All student support services will be provided to the student through a single window method/mode onsite and online.

F. Procedure for Admissions, Curriculum, Transaction and Evaluation

Admission Process

Admission to the M.Sc. (Chemistry) Programme will be done on the basis of screening of candidate's eligibility on first come first serve basis. The University will follow the reservation policy as per norms of the Government. Admission shall not be a right to the students and MU, CDOE shall retain the right to cancel any admission at any point of time if any irregularity is found in the admission process, eligibility etc..

Maximum Duration

A. The maximum duration of the M.Sc. (Chemistry) Programme is four years. Thereafter, students seeking completion of the left-over course(s) will be required to seek fresh admission.
B. The student can complete his programme within a period of 4 years failing which he/she shall seek fresh admission to complete the programme.

Eligibility

Science (PCM/PCMB) Graduate from a recognised University is eligible for admission into M.Sc. (Chemistry) programme.

Fee Structure

Name of the Program	Degree	Duration	Year	Tuition Fee/Year	Exam Fee/Year	Total (in Rs.)
Master of Science (Chemistry)	PG	2 to 4 Years	1	15000	2000	17000
			2	13500	2000	15500
Total						32500

Activity Schedule

S. No.	Name of the Activity	Tentative months schedule (specify months) during year			
		From	To	From	To
1	Admission	Jul	Sep	Jan	Mar
2	Assignment submission (if any)	Sep	Oct	Mar	Apr
3	Evaluation of Assignment	Oct	Nov	Apr	May
4	Examination	Dec		Jun	
5	Declaration of Result	Jan		Jul	
6	Re-registration	Jul		Jan	
7	Distribution of SLM	Jul	Sep	Jan	Mar
8	Contact Programmes (counseling, Practicals.etc.)	Sep	Nov	Mar	May

Credit System

MU, CDOE proposes to follow the 'Credit System' for most of its programs. Each credit amounts to 30 hours of study comprising all learning activities. Thus, a 8 credit course requires 240 hours, 6 credit course requires 180 hours , 4 credit course requires 120 hours and 2 credit course requires 60 hours of study. This helps the student to understand the academic effort to complete a course. Completion of an academic programme requires successful clearing of both, the assignments and the term-end examination of each course in a programme.

Duration of programme	Credits	Name of programme	Level of programme
2 to 4 Yrs.	80	M.Sc. (Chemistry)	Master's Degree

Assignments

Distance Education learners have to depend much on self study. In order to ascertain the writing skill and level of comprehension of the learner, assignment work is compulsory for all learners. Each assignment shall consist of a number of questions, case studies and practical related tasks. The Assignment Question Papers will be uploaded to the website within a scheduled time and the learners shall be required to respond them within a specified period of time. The response of the learner is examined by a faculty member.

Evaluation: The evaluation system of the programme is based on two components:

A. Continuous Evaluation in the form of assignments (weightage 30%): This Component carries a weightage of 30%. There will be at least one graded assignment and test per course. These

assignments are to be submitted to the Co-ordinator of the CDOE/Study Centre to which the student is assigned or attached with.

B. Term-end examination (weightage 70%): This will be held twice every year in the months of June and December. The students are at liberty to appear in any of the examinations conducted by the University during the year. A student will be allowed to appear in the Term-End Examination only after she/he has registered for that course and submitted the assignment. For appearing in the Examination, every student has to submit an Examination form through online (www.mangalayatan.in)/ or offline before the due dates as given in the schedule of operations. If a student misses any term-end examination of a course for any reason, s/he may appear for any of them or all the courses subject to the maximum of 8 courses in the subsequent term-end examinations. This facility will be available until a student secures the minimum pass grade in the courses but up to a maximum period of four semesters, since the date of registration of the course is valid for four semesters. Beyond this period s/he may continue for another four semesters by getting Re-registration by paying fee again. In that case, the score of qualified assignments and/or term-end examination will be retained and the student will be required to complete the left out requirements of such re-registered courses. Minimum requirement for passing a course will be 40% marks.

G. Laboratory Support and Library Resources

The library of Mangalayatan University aims to empower the teaching mission and intellectual culture of the community through availability through an organized collection of information as well as instruction in its access, relevance and evaluation. The University Library enriches advance learning and discovery by providing access to a broad array of resources for education, research and creative work to ensure the rich interchange of ideas in the pursuit of knowledge.

The Centre of Distance Education of Mangalayatan University has initiated the process of setting up a dedicated Library for ODL program and acquiring printed books and e-books for this purpose. The required International and National subject journals are also provided. We have a full functioning community radio service onboard (90.4 FM). We already have annual journal subscriptions and the capacity can be enlarged at later stages as the University lines up with more online journals.

The collection of the Library is rich and diverse especially in terms of the breadth and depth of coverage. Collection encompasses subjects in Management, Commerce, Information Technology, Computer Applications, and other allied areas. This collection further includes Books, Research Journals, Project Reports/Dissertations and online Journals.

The Chemistry laboratory is well equipped with chemicals, reagents as well as instruments which are necessary for practical analysis.

The University has well equipped Computer Laboratories, Lecture Capturing Systems, Audio Video facilities, ICT enabled class rooms, Wi-Fi facilities etc.

H. Cost estimate of the programme and the provisions

Initial expenses have been done by the University in terms of provision of infrastructure, manpower, printing of Self Study Material etc. The University intends to allocate expenses out of the total fee collection as per following details:

a) SLM Development and Distribution : 20%
b) Postal and ICT Expenses : 10%
c) Salary and other Administrative expenses : 60%
d) Future Research development reserve : 10%

Once programmes are operational, the programme budget from fee receipts will be planned as per the guidelines of University Grants Commission.

I. Quality Assurance

The University has established the Centre for Internal Quality Assurance (CIQA) in the University campus. The CIQA will monitor and maintain the quality of the ODL programmes. It has the following objectives in making the compliances of quality implementations.

Objectives

The objective of Centre for Internal Quality Assurance is to develop and put in place a comprehensive and dynamic internal quality assurance system to ensure that programmes of higher education in the Open and Distance Learning mode and Online mode being implemented by the Higher Educational Institution are of acceptable quality and further improved on continuous basis.

Functions of CIQA

The functions of Centre for Internal Quality Assurance would be following:

1) To maintain quality in the services provided to the learners.
2) To undertake self-evaluative and reflective exercises for continual quality improvement in all the systems and processes of the Higher Educational Institution.
3) To contribute in the identification of the key areas in which Higher Educational Institution should maintain quality.
4) To devise mechanism to ensure that the quality of Open and Distance Learning programmes and Online programmes matches with the quality of relevant programmes in conventional mode.
5) To devise mechanisms for interaction with and obtaining feedback from all stakeholders namely, learners, teachers, staff, parents, society, employers, and Government for quality improvement.
6) To suggest measures to the authorities of Higher Educational Institution for qualitative improvement.
7) To facilitate the implementation of its recommendations through periodic reviews.
8) To organize workshops/seminars/symposium on quality related themes, ensure participation of all stakeholders, and disseminate the reports of such activities among all the stakeholders in Higher Educational Institution.
9) To develop and collate best practices in all areas leading to quality enhancement in services to the learners and disseminate the same all concerned in Higher Educational Institution.
10) To collect, collate and disseminate accurate, complete and reliable statistics about the quality of the programme(s).
11) To ensure that Programme Project Report for each programme is according to the norms and guidelines prescribed by the Commission and wherever necessary by the appropriate regulatory authority having control over the programme;
12) To put in place a mechanism to ensure the proper implementation of Programme Project Reports.
13) To maintain a record of Annual Plans and Annual Reports of Higher Educational Institution, review them periodically and generate actionable reports.
14) To provide inputs to the Higher Educational Institution for restructuring of programmes in order to make them relevant to the job market.
15) To facilitate system based research on ways of creating learner centric environment and to bring about qualitative change in the entire system.
16) To act as a nodal coordinating unit for seeking assessment and accreditation from a designated body for accreditation such as NAAC etc.
17) To adopt measures to ensure internalization and institutionalization of quality enhancement practices through periodic accreditation and audit.
18) To coordinate between Higher Educational Institution and the Commission for various qualities related initiatives or guidelines.
19) To obtain information from other Higher Educational Institutions on various quality benchmarks or parameters and best practices.
20) To record activities undertaken on quality assurance in the form of an annual report of Centre for Internal Quality Assurance.

21) It will be mandatory for Centre for Internal Quality Assurance to submit Annual Reports to the Statutory Authorities or Bodies of the Higher Educational Institution about its activities at the end of each academic session. A copy of report in the format as specified by the Commission, duly approved by the statutory authorities of the Higher Educational Institution shall be submitted annually to the Commission.

After enrolling in M.Sc. (Chemistry) programme of Mangalayatan University in ODL mode, student will exhibit knowledge, skill and general competence with scientific aptitude and innovation. After completion of M.Sc. (Chemistry) programme, student will pursue further studies in Chemistry for roles in academia, research, industry, laboratory, technology and government.