

Syllabus for M.Sc. Chemistry

w.e.f. July 2013

Semester I

Course Code	Course Title	Course Credit Hours
CHEM- 711	Inorganic Chemistry I	3(2-0-2)
CHEM- 712	Organic Chemistry I	3(2-0-2)
CHEM- 713	Physical Chemistry I	3(2-0-2)
CHEM- 714	Analytical Chemistry	3(2-0-2)
COMP- 705	Computer Orientation	3(2-0-2)
CHEM- 717	Environmental & Supramolecular Chemistry	3(2-0-2)

Semester II

CHEM- 721	Inorganic Chemistry II	3(2-0-2)
CHEM- 722	Organic Chemistry II	3(2-0-2)
CHEM- 723	Physical Chemistry II	3(2-0-2)
CHEM- 724	Catalysis and Green Chemistry	3(3-0-0)
CHEM- 811	Spectroscopy	3(3-0-0)
CHEM- 812	Chromatographic Techniques	3(2-0-2)
CHEM- 780	Seminar I	1(0-1-0)

Semester III

CHEM- 813	Bio-inorganic and Medicinal Chemistry	3(2-0-2)
CHEM- 815	Natural Products and Organic Synthesis	3(2-0-2)
CHEM- 818	Thermodynamics	3(3-0-0)
CHEM- 822	Nanochemistry	3(3-0-0)
CBBI- 802	Chemoinformatics	3(2-0-2)
CHEM- 880	Seminar II	1(0-1-0)
CHEM-899	Dissertation	8

Elective (any one)

CHEM- 823	Inner transition elements & Electronic Spectra	3(3-0-0)
CHEM- 825	Organic Photochemical Reactions	3(3-0-0)
CHEM- 828	Advanced spectroscopy	3(3-0-0)

Semester IV

CHEM- 899	Dissertation	22
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M.Sc. CHEMISTRY
SEMESTER I

CHEM-711

INORGANIC CHEMISTRY I

Credits-3(2-0-2)

Unit I: Chemical periodicity, Main group elements and their compounds : Allotropy, synthesis, structure and bonding, industrial importance of the compounds.

Unit II: Structure and bonding in homo and heteronuclear molecules, including shapes of molecules (VSEPR Theory).

Unit III: Chemical bonding in diatomics; elementary concepts of MO and VB theories. **Unit IV :** Nuclear chemistry: nuclear reactions, fission and fusion, radio – analytical mtechniques and activation analysis.

Practical:

1. Qualitative analysis of inorganic mixtures including rare earth elements.
2. Qualitative analysis of inorganic mixture with interfering acid radicals.

Books Recommended:

Inorganic Chemistry by Shriver & Atkins (Oxford)

Text book of inorganic Chemistry by P.L. Soni (S.Chand)

Advanced Inorganic Chemistry by Gurdeep Raj

Practical Inorganic Chemistry by Vogel (CBS)

University Practical Chemistry by PC Kamboj (Vishal Publication)

CHEM-712

ORGANIC CHEMISTRY I

Credits-3(2-0-2)

Unit I: IUPAC nomenclature of organic molecules including region-and stereoisomers.

Unit II: Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.

Unit III: Aromaticity: Benzenoid and non-benzenoid compounds – generation and reactions.

Unit IV: Organic reactive intermediats; Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzyne and nitrenes.

Unit V: Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

Practical

1. Identification of various compounds with different functional groups
-Acids, carbohydrates, phenols, aldehyde, ketones, amides and hydrocarbons

Books Recommended

1. Organic chemistry by Morrison and Boyd
2. A logical approach to modern organic chemistry-Jagdamba Singh and Anand Vardhan
3. Advanced Organic Chemistry Reaction, Mechanism and structure – Jerry March
4. A Guidebook to mechanism in Organic Chemistry-Peter Sykes

Unit I : Electrochemistry : Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; Reversible & Irreversible cells and types of reverse bell electros.

Unit II : Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; photochemical reactions.

Unit-III: Colloidal Chemistry Characteristics of lyophilic and lyophobic solution, preparation, purification and properties (optical, kinetics and electrical), Gold number, electrophoresis, associated colloid, cleaning action of soap and detergents, emulsion, gels and its application.

Practical:-

To study the kinetics of decomposition of sodium thiosulphate by mineral acids

To study the kinetics of dissolution of Mg in dilute HCl

To determine the velocity constant for the hydrolysis of Methyl acetate, catalysed by hydrogen ions.

Determination of concentration of unknown solution using drop weight method.

Determination of λ max of KMnO_4 solution and findings the concentration of unknowns solutions by using absorptions photometer.

Determine the comparative viscosity of different liquids.

Determination of iron with KMnO_4

Determination of iron by $\text{K}_2\text{Cr}_2\text{O}_7$ (using external indicators)

Books Recommended:-

Bahel, Dubey, Nath

P.c. Kamboj

Pandey, Bajpai, Giri

Puri, Sharma, Pathania

Bahel and Tuli

Gurdeep Raj

K.L. Kapoor

Unit I : Introduction to Analytical Chemistry- Methods of qualitative and quantitative analysis.

UNIT II:Thermal Analysis: Introduction, types and applications of thermo analytical methods, Thermo gravimetric.

UNIT III : Electro Analytical Techniques: Voltametry, Amperometry, Coulometry, Conductometry, Potentiometry.

UNIT IV : Diffraction Techniques: Introduction, types and application

UNIT V : Electrochemical Techniques:Introduction and application of Electrolysis, Electrophoresis

Practical:-

1. Preparation of standard solutions and standardization of unknown solutions.
2. Volumetric and Gravimetric estimation of organic and inorganic compounds.
3. Verification of Beer's law and colorimetric determinations.
4. Turbiditometric determinations
5. Instrumentation of Spectrophotometer

Books Recommended:-

1. Analytical Chemistry by Gary Christian (Wiley)
2. Quantitative Analysis by Day and Underwood
3. Instrumental Methods of Chemical Analysis by B. K. Sharma
4. Instrumental methods of Analysis by Willard, Merritt, Dean, Settle (CBS).

Unit I : Information Concepts**Unit II :** Computer Basics

- a. Definition, Characteristics & Application of Computers
- b. Computer Hardware: I/O Devices, memory, CPU
- c. Software Concepts

Unit III : Operating Systems

- a. DOS
- b. Windows

Unit IV : Application Software

- a. MS Word
- b. MS Excel

Unit V : Computer Programming

- a. Algorithm & Flowchart
- b. Introduction to 'C' Language
 - i. History
 - ii. Input & Output Statements
 - iii. Variables & Constants
 - iv. Expressions & Operators
 - v. Control Statements
 1. Branching Statements (if, if- else, Nested if)
 2. Looping Statements (while, do-while, for)
 - vi. Functions & Arrays

1. Internet Concepts & Search Engine.
2. Application of statistical packages.

Reference Books:

1. J.B. Dixit, "Fundamentals of Computers & Programming in 'C'", Laxmi
2. Publications(P) Ltd. Yashavant Kanetkar, "Let us C", BPH Publications
3. E. Balaguruswamy, "ANSI C", TMH

Practical List

1. Demo session on computer & its components, I/O devices, Memory, CPU.
2. **MS DOS:**
Internal DOS Commands: md, cd, dir, time, del, type, edit, copy, exit, path, prompt, rem, ren, ver.
External DOS Commands: attrib, backup, chkdsk, diskcomp, diskcopy, doskey, format, label, xcopy, move, tree, undelete.
3. **Windows:** Login, Desktop, Icons & Folders, Taskbar, Changing Desktop properties, My computer, My Network places, Recycle bin, My Documents, Control panel.
4. **Application Software:**
MS Word: Getting familiar with various tool bars, Tables and Columns, Mail merge.
MS Excel: Working with Spreadsheets, Mathematical & Statistical functions, Generating Charts, Creating Macros.
5. **C Programming :**
 - Programs illustrating use of printf()and scanf() statements
 - Practicing with decision making statements like IF, IF-ELSE, Nested IF, ELSE-IF Ladder, Switch, Goto
 - Working with loops
 - Illustration of Arrays
 - Designing programs to demonstrate concept of functions
6. Internet: Webpage, website, browser, URL, Surfing, Searching, creating mail accounts.
7. A glance over statistical packages like SPSS, MATLAB etc.

CHEM-717

**ENVIRONMENTAL &
SUPRAMOLECULAR CHEMISTRY**

Credits-3(2-0-2)

Unit I : Polymer chemistry; kinetics of polymerization.

Unit II: Polymer basic, classification, structural - property correlation in polymers, methods to determine the molecular weight of polymers, engineering polymers. biodegradable polymers, polymer degradation mechanisms and biodegradation aspects, waste management.

Unit III : Environmental segments and pollutants.

Unit IV : Trace elements – Pollution and control.

Unit V : Sustainable development – New approaches.

SEMESTER II

CHEM-721

INORGANIC CHEMISTRY II

Credits-3(2-0-2)

Unit I : Transition elements and coordination compounds : structure, bonding theories, spectral and magnetic properties, reaction mechanisms.

Unit II : Organometallic compounds : synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.

Unit III : Cages and metal clusters.

Practical

1. Volumetric estimation using EDTA, Ammonium vanadate, ceric sulphate, chloramines-t and potassium iodate.
2. Colorimetric determination of Cr, Fe, Mn, Ni, Ti, W and Cu.
3. Preparation of metal complexes.

Books Recommended :

Theoretical Inorganic Chemistry by M.C. Day and J. Selbin,
Modern Aspects of Inorganic Chemistry by H.J. Emelens and A.G. Sharp.. (Van).
Text book of Inorganic Chemistry by P.L. Soni (S. Chand)
Inorganic Chemistry by Shriver & Atkins
Text book Quantitative Inorganic Analysis by A.I. Vogel
Experimental Inorganic Chemistry by W.G. Parmer

CHEM-722

ORGANIC CHEMISTRY II

Credits-3(2-0-2)

Unit I : Common named reactions and rearrangements – applications in organic synthesis.

Unit II : Organic transformations and reagents: Functional group interconversion including oxidations and reductions and common catalysis and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations.

Unit III : Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.

Unit IV : Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic.

PRACTICAL

1. Separation of mixtures containing two compounds
2. With (a) water (b) NaHCO₃ (c) NaOH
3. Determination of Saponification and Iodine value of oil sample.
4. Qualitative method for the identification of aqueous solutions of carbohydrates- Glucose, fructose, starch, sucrose, lactose and maltose

Books Recommended

1. Organic chemistry by Morrison and Boyd
2. Advanced Organic Chemistry Reaction, Mechanism and structure – Jerry March
3. A Guidebook to mechanism in Organic Chemistry-Peter Sykes
4. Reaction Mechanism by Singh & Mukherji

Unit I: Introduction and Principles of Quantum Chemistry: The structure of hydrogenic atoms, atomic orbital and their energies. The failures of classical physics, Wave – particle duality, Impact on biology: Information in a wave function, Uncertainty Principle, The Postulates of quantum mechanics.

Unit II: Motion of a Particle: A particle in a box, motion in two or more directions, tunneling, The energy levels, The wave functions, harmonic oscillator, Impact on nano science.

Unit-III: Physical chemistry of polymers and macro molecules number- average and weight average molecular weight, determination of molecular weight, kinetics of polymerization and its mechanism.

Unit-IV: Thermo Chemistry Heat of reaction, heat of Combustion, heat of Solution, heat of Neutralization, energy change during transition or phase change, heat of fusion, heat of Vaporization, heat of Sublimation, heat of Transition, Hess's law of heat Summation and its applications.

Practical:

1. The rate constant of reaction between acetone and iodine in presence of mineral acid and a catalyst and to show that this reaction with respect to iodine is of zero order.
2. The absorption of aqueous acetic acid by activated charcoal and to study the absorption isotherm.
3. To prepare the solution of Arsenious sulphide, ferric hydroxide, Sulphur and Aluminum hydroxide solution.
4. To determine the heat of Neutralization of NaOH and HCl.
5. To determine the molecular weight of the given substance (Glucose/Sucrose/Urea etc). cryscopically using water as the solvent with the help of Beckmann's thermometer.
6. Determination of rate constant of the hydrolysis of methyl acetate by Sodium Hydroxide.

Books Recommended:-

1. Puri, Sharma, Pathania
2. Bahl and Tuli
3. Gurdeep Raj
4. K.L. Kapoor

UNIT I- Basic Principles of Green Chemistry:- Prevention of waste by products, maximum incorporation of the reactants into the final product, prevention or minimization of hazardous products, designing safer chemicals, energy requirements for synthesis, selection of appropriate solvent, selection of starting materials, use of protecting groups, use of catalyst, products designed be biodegradable, designing of manufacturing plants & strengthening of analytical techniques.

UNIT II- Green Reagent:- Dimethylcarbonate, polymer supported reagent, polymer supported peracids, poly, eric thioanisoyl resin. Poly-N-bromosuccinimide (PNBS), sulfonazide polymer, polystyrene wittig reagent & polymer supported peptide coupling agent.

UNIT III- Green Catalyst:- Acid catalyst, oxidation catalyst, basic catalyst, polymer supported catalyst, polystyrene – aluminium chloride, polymer supported photosensitizers, miscellaneous illustration & solid support reagents.

UNIT IV- Aqueous Phase Reactions:- Diels-Alder reaction, Claisen rearrangement, Wittig-Horner reaction, Michael reaction, Aldol condensation, Knoevenagel reaction, Pinacol coupling, Benzoin condensation Claisen-Schmidt condensation. Strecker synthesis, Wurtz reaction, Oxidations, Reductions, Polymerization reactions, Photochemical reactions, Electrochemical synthesis & Miscellaneous reactions in Aqueous Phase.

Books Recommended

1. New Trends in Green Chemistry by V.K. Ahluwalia, M.Kidwai(Anamaya Publishro New Delhi)
2. Introduction to Green Chemistry by V.Kumar.

CHEM-811**SPECTROSCOPY****Credits-3(3-0-0)**

UNIT I : Electromagnetic Radiations:- Interaction of EM-radiations with matter, scattering, dispersion and transmission of radiation.

UNIT II : UV-Visible Spectroscopy:- Nature of electronic excitation, origin of UV- band structure, principle of adsorption spectroscopy, instrumentation, presentation of spectra chromophore, Woodward Fieser rules for dienes.

UNIT III : IR (vibrational) Spectroscopy:- Infra red absorption process, stretching and bending, Infra Red Spectrometer, IR-Spectrum, application of IR Spectrum.

UNIT IV : Mass Spectrometry:- Basic principles, theory, instrumentation, mass spectrum, the nitrogen rule, general fragmentation modes, important features in mass spectroscopy, simple problems in mass spectroscopy.

UNIT V : Proton NMR. C^{13} – NMR(H^1 - NMR) Spectroscopy, Raman Spectroscopy.

Books Recommended:-

Spectroscopy- Pavia, Lampman, Kriz, Vyuyan.
Elementary Organic Spectroscopy by Y.R. Sharma
Spectroscopy by P.S. Kalsi
Spectroscopy by H.Kaur.
Organic Spectroscopy by William Kemp
Spectroscopic Methods by Sylverstein.

CHEM-812**CHROMATOGRAPHIC TECHNIQUES****Credits 3(2-0-2)**

UNIT I : Partition Chromatography: Paper chromatography, Thin Layer Chromatography, R_f value, chromatogram, single, 2D and 3D chromatography. Ascending and descending chromatography. Applications of partition chromatography.

UNIT II : Adsorption Chromatography:- Principle, classification of column chromatography, column efficiency, preparation of column.

UNIT III : Ion Exchange Chromatography:- Structure of ion exchanger, types of cation and anion exchanger, mechanism of ion exchange chromatography. Ion exchange resins, ion exchange capacity. Factors affecting separations, applications of IEC.

UNIT IV : Exclusion Or Gel Chromatography:- Technique in Gel Chromatography, Gel preparation, packing of column, theory and application of gel chromatography

UNIT V : H.P.L.C.:- Principle, instrumentation, advantages of HPLC, Effect of temperature in HPLC, HPTLC, Applications of HPLC and HPTLC.

UNIT VI : Gas Chromatography:- Principle, G.C. columns, Instrumentation, Methodology, GC-MS, applications of GC.

Practical:- 1. Separation of Ions, molecules by descending (2D, 3D) Chromatography.
Separation of molecules by Column Chromatography.
Separation of ions using ion exchangers

Books Recommended:-

1. Analytical Chemistry by Gary Christian (Wiley)
2. Quantitative Analysis by Day and Underwood
3. Instrumental Methods of Chemical Analysis by B. K. Sharma
4. Instrumental methods of Analysis by Willard, Merritt, Dean, Settle (CBS).

SEMESTER III**CHEM-813 BIO-INORGANIC AND MEDICINAL CHEMISTRY Credits-3(2-0-2)**

Unit I : Bioinorganic chemistry : photosystems, porphyrins, metalloenzymes, oxygen transport, electron – transfer reactions; nitrogen fixation, metal complexes in medicine .

Unit II: General Structure, Stereochemistry, Mode of action, Structure activity relationships, specific clinical applications of Pharmaceutical drugs

Unit III: Antibacterials: penicillins, cephalosporins, tetracyclins, aminoglycosides, chloramphenicols, macrolides, lincomycins, polypeptides antibiotics, polyene antibiotics. Sulfonamides and sulfones, fluroquinolines, trimethoprim and other unclassified antibiotics.

Antimycobacterials: Sulfanilamides, p- aminosalicylic acid derivatives, thioamides, thiourea derivatives, thiosemicarbazones.

Unit IV: Antimalerials: Cinchona alkaloids, 4- aminoquinolines, 9- aminoacridines, Biguanides, pyrimidines and sulfones, mefloquine, sulfonamides.

CHEM-815 NATURAL PRODUCTS AND ORGANIC SYNTHESIS Credits-3(2-0-2)

Unit I : Pericyclic reactions – electrocycloisatation, cycloaddition, sigmatropic rearrangements and other related concerted reactions.

Unit II : Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).

Unit III : Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.

Practical

1. Separation of amino acids by Thin layer chromatography method
2. Synthetic preparation and yield determination of
 - (a) Benzamide from benzoyl chloride
 - (b) Picric acid from phenol
 - (c) Osazone derivative from glucose
 - (d) Benzoate derivative of phenol
 - (e) Preparation of dye from nitrobenzene
3. Extraction of essential oil by Cleavanger's apparatus.

Books Recommended:

- (1) Organic Chemistry by J.L. Finar
 - (2) Organic Chemistry by O.P. Agarwal
 - (3) A logical approach to modern organic chemistry-Jagdamba Singh and Anand Vardhan
- Fundamental concepts of Applied Chemistry by Jayashree Ghosh

CHEM-818

THERMODYNAMICS

Credits-3(3-0-0)

Unit I : Chemical thermodynamics : Laws, states and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle.

Unit II : Statistical Thermodynamics: Thermodynamics probability and entropy, Maxwell- Boltzmann, Bose-Einstein and Fermi-dirac statistics. Partition function; rotational translational, vibrational and electronic partition function and their relation to thermodynamic quantities.

Books Recommended:-

1. Puri, Sharma, Pathania
2. Bahl and Tuli
3. Gurdeep Raj
4. K.L. Kapoor

CHEM-822

NANOCHEMISTRY

Credits 3(3-0-0)

UNIT I : Introduction: History scope and perspectives of nano-chemistry

UNIT II : Synthesis and Stabilization of Nanoparticles, Chemical Reduction; Reactions in Micelles, Emulsions, and Dendrimers; Photochemical and Radiation Chemical Reduction; Cryochemical Synthesis: Physical Methods, Particles of Various Shapes and Films.

UNIT III : Experimental Techniques: Electron Microscopy: Transmission electron microscopy: Probe Microscopy: Probe Microscopy: Diffraction Techniques X-ray diffraction, Neutron diffraction : Miscellaneous Techniques, Comparison of Spectral Techniques Used for Elemental Analysis

UNIT IV : Size Effects in Nanochemistry: Models of Reactions of Metal Atoms in Matrices; Properties; Kinetic Peculiarities of Chemical Processes on the surface of Nanoparticles; Thermodynamic Features of Nanoparticles.

UNIT V : Applications of Nanoparticle in various fundamental research, industries, medical field and environmental issue; toxicity, biosafety and ethical issue in application of Nanoparticle

Books Recommended:

1. Nanomaterials and Nanochemistry, Br'echignac C., Houdy., and Lahmani M. (Eds.) Springer Berlin Heidelberg New York. 2007.
2. Nanoparticle Technology Handbook. M. Hosokawa, K. Nogi, M. Naito and T. Yokoyama (Eds.) First edition 2007. Elsevier
3. Nanotechnology Basic Calculations for Engineers and Scientists. Louis Theodore, John wiley & sons, inc., publication, 2006.

CBBI-802

CHEMOINFORMATICS

Credits 3(2-0-2)

UNIT I : Role of computers in chemical research, Introduction to Chemoinformatics, Representation and manipulation of 2D and 3D molecular structures, Chemical Databases- Design, Storage & Retrieval methods.

UNIT II : Reaction databases, Representation of chemical reactions, Search techniques(Full, Sub and Super structure), Similarity searches, Modelling of small molecules.

UNIT III : Combinatorial chemistry and Library design –Introduction, Data visualization, Data mining methods, Prediction of ADMET properties, Chemoinformatics tools for drug discovery.

Practical:

1. To draw and analyze the chemical structures by using the ChemSketch/ChemDraw software.
2. To convert the chemical structure data from one file format to other file formats by using the CHIMERA/BABEL software.
3. To study about the different types of chemical structure database.
4. To visualize the chemical structure in different views by using the visualization softwares.
5. To calculate the descriptors of few ligands by using the DRAGON software.
6. To perform the virtual screening of ligands by using the AUTODOCK programme.

Books Recommended

An Introduction to Chemoinformatics by Andrew R. Leach, V.J. Gillet

Chemoinformatics by Johann Gas teiger

Chemoinformatics: Theory, Practice & Products by Bunin., Siesel, B., Morales, G., Bajorath, J.

CHEM- 880

SEMINAR II

Credit 1(0-1-0)

CHEM- 899

DISSERTATION

Credit: 8

Elective (Any One)

CHEM-823

**INNER TRANSITION ELEMENTS &
ELECTRONIC SPECTRA**

Credits-3(3-0-0)

Unit I : Inner transition elements : spectral and magnetic properties, redox chemistry, analytical applications.

Unit II : Concepts of acids and bases, Hard – soft acid base concept, Non- aqueous solvents.

Books Recommended:

1. Inorganic chemistry by Shriver & Atkins.(Oxford)
2. Advance Inorganic Chemistry, Cotton Wilkinson.
3. Advanced Inorganic Chemistry by Simon Cotton.

CHEM-825 ORGANIC PHOTO CHEMICAL REACTIONS Credits-3(3-0-0)

Unit I : Principles and applications of photochemical reactions in organic chemistry.

CHEM-821 ADVANCED SPECTROSCOPY Credits 3(2-0-2)

UNIT I : Principle, theoretical treatments and applications of following-

- (a) Atomic Absorption Spectroscopy
- (b) Flame Emission Spectroscopy
- (c) Proton NMR. C^{13} – NMR(H^1 - NMR) Spectroscopy
- (d) Raman Spectroscopy
- (e) Mossbauer and Photoelectron Spectroscopy

Reference Books:-

1. Spectroscopy- Pavia, Lampman, Kriz, Vyuyan
2. Elementry organic Spectroscopy – Y. R. Sharma.
3. Spectroscopy – P.S. Kalsi
4. Spectroscopy- H.Kaur.
5. Organic Spectroscopy – William kemp
6. Spectroscopic Methods – Sylnerstein.

Semester IV

CHEM- 899

DISSERTATION

Credit: 22