UNIVERSITY OF LUCKNOW
MASTERS OF CHEMISTRY PROGRAMME
REGULATION 2020

1. APPLICABILITY

These regulations shall apply to the Masters in Chemistry programme from the session 2020-21.

2. Minimum eligibility for admission

A three/four years Bachelor's degree or equivalent with chemistry as one of the subject in final year awarded by University or Institute established as per law and recognized as equivalent by university with minimum 45% marks for general and OBC (SC/ST 40%) or equivalent grade shall constitute the minimum requirement for admission to the Masters in Chemistry Programme.

3. Programme Objectives

I. To enable the students to learn about the Periodic Table, Coordination Chemistry and Structure of Molecules, Properties of Compounds, Structural Determination of Complexes using theories and instruments.
II. To make the students to learn about the physical aspects of Atomic Structure, Dual Behaviour, Reaction Pathways with respect to time, various Energy Transformations, Molecular assembly at Nanolevel, Significance of Electrochemistry, Molecular Segregation using their symmetry.
III. To learn about the potential uses of Analytical, Industrial and Medicinal chemistry.
IV. To understand and apply principles of Organic Chemistry for understanding the Reaction mechanisms, Stereochemistry, Organic Synthesis, complex chemical structures, instrumental method of chemical analysis, Molecular rearrangements and separation techniques. To carry out laboratory experiments taught in Core Theory papers and to learn the principles of good laboratory practices.
V. To help the studentsôdevelop ability to make mathematical models for physical systems.
VI. To inculcate interest in research and provide to exposure to various research methodologies.

1. Programme Outcomes

PO-1. Demonstrate, solve and an understanding of major concepts in all disciplines of Chemistry independently and in group as well as draw logical conclusions through Project and Seminar Presentation.
PO-2. Employ critical thinking and the scientific knowledge to design, carry out, record and analyze the results of Chemistry experiments
PO-3. Equip students to face the employment challenges and instil confidence to turn into entrepreneur and also step into research career.
PO-4. Generation of new scientific insights or to the innovation of new applications of chemical research
PO-5. Present scientific and technical information resulting from laboratory experimentation in both written and oral formats.
PO-6. Apply modern methods of analysis to chemical systems in a laboratory setting.
PO-7. The students will become well versed in the mechanisms of all types of high level and complicated chemical reactions.
PO-8. The students will improve their competencies on par with their counterparts in premier institutions across the nation.

4. Programme Specific Outcomes

PSO-1. Appreciates the importance of various elements present in the periodic table, coordination chemistry and structure of molecules, properties of compounds, structural determination of complexes using theories and instruments.
PSO-2. Gathers attention about the physical aspects of atomic structure, dual behaviour, reaction pathways with respect to time, various energy transformations, molecular assembly in nanolevel, significance of electrochemistry, molecular segregation using their symmetry.
PSO-3. Learns about the potential uses of analytical, industrial chemistry and medicinal chemistry.
PSO-4. Understand and apply principles of Organic Chemistry for understanding the scientific phenomenon in Reaction mechanisms, Stereochemistry, Organic Synthesis, complex chemical structures, instrumental method of chemical analysis, molecular rearrangements and separation techniques.

PSO-5. Study of organometallic reactions.
PSO-6. Study of biological mechanisms using amino acids.
PSO-7. Learn the classical status of thermodynamics.
PSO-8. Carry out laboratory experiments taught in Core Theory papers and to understand good laboratory practices with safety.
PSO-9. Enhance studentsôability to develop mathematical models for physical systems.
PSO-10. Global level research opportunities to pursue Ph.D. programme targeted approach of CSIR/UGC ï NET examination
PSO-11. Discipline specific competitive exams conducted by service commission

5. Course Structure

The course structure of the Masters in Chemistry programme shall be as under.

No.	Name of the Couse	Credit	Remark
	Semester I		
CHCC-101	Inorganic Chemistry	**04**	Core Course
CHCC-102	Organic Chemistry	**04**	Core Course
CHCC-103	Physical Chemistry	**04**	Core Course
CHCC-104A CHCC-104B CHCC-104C	Inorganic Chemistry Practical Organic Chemistry Practical Physical Chemistry Practical	**04** **04** **04**	Core Course
CHVNC-101	* Separation Techniques Or * Chemistry of Analgesics and Antipyretics	**00**	Value Added (Non Credited)
	Semester Total	**24**	
	Semester II		
CHCC-201	Inorganic Chemistry	**04**	Core Course
CHCC-202	Organic Chemistry	**04**	Core Course
CHCC-203	Physical Chemistry	**04**	Core Course
CHCC-204A CHCC-204B CHCC-204C	Inorganic Chemistry Practical Organic Chemistry Practical Physical Chemistry Practical	**04** **04** **04**	Core Course
CHVNC-201	* Science of Technology of Cosmetics Or * Bioethanol as Fuel	**00**	Value Added (Non Credited)
	Semester Total	**24**	
	Semester III		
CHCC-301	Inorganic Chemistry	**04**	Core Course/MOOC
CHCC-302	Organic Chemistry	**04**	Core Course
CHCC-303	Physical Chemistry	**04**	Core Course
CHCC-304	Advance Chemistry Practical-I	**04**	Core Course
CHEL-301A CHEL-301B	Environmental Chemistry Chemistry of Natural Products	**00**	Elective (Non Credited)
CHIN-301	Summer Internship	**04**	Summer Internship
CHIER-301	Concepts of Chemistry	**04**	Interdepartmental
	Semester Total	**24**	
	Semester IV		
CHCC-401	Advanced Chemistry Practical-II	**04**	Core Course
Any one papers from each CHEL-402A, CHEL-402B and CHEL-402C			
CHEL-402A	Bioinorganic and Supramolecular Chemistry Or Organotransition Metal Chemistry	**04**	Elective/ Intradepartmental

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No.	Name of the Couse	Credit	Remark
CHEL-402B	Organic Synthesis Or Medicinal Chemistry	**04**	Course
CHEL-402C	Polymer Chemistry Or Electrochemistry	**04**	Elective/ Intradepartmental Course
CHMT-401	Project and Dissertation, Evaluation and Viva-voce on submitted Dissertation (Internal)	**08**	Master Thesis
	Semester Total	**24**	
	GRAND TOTAL	**96**	

* The offered courses shall be announced by the Head, Chemistry Department in the beginning of session every year.

CH – Subject; CHCC – Core Course; CHVNC –Value Added (Non-credited); CHEL – Elective; CHIER – Interdepartmental Course; CHIRA – Intradepartmental Course

Course Outlines

PROGRAMME STRUCTURE

The Master of Science in Chemistry is a Two Year Full Time Course consisting of Four Semesters.
Semester I
Semester II
Semester III
Semester IV

Sem	Core Course			Elective Course			Open elective Course			Value Added		Total Credits
	No. of Papers	Credits (L+T/P	Total Credit	No. of Paper	Credits (L+T/P)	Total Credit	No. of Paper	Credits (L+T/P	Total Credit	No. of Papers	Credits	
I	4	12+12	24	0	0+0	0	0	0+0	0	1	0	24
II	4	12+12	24	0	0+0	0	0	0+0	0	1	0	24
III	5	12+8	20	0	0+0	0	1	4+0	4	0	0	24
IV	2	4+8	12	3	4+4+4	12	0	0+0	0	0	0	24
Total Credits			80			12			4		0	96

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Semester III Syllabus
Core Course/MOOC
Paper Code CHCC-301: Inorganic Chemistry

Credits: 04 **Hours: 60**

Course Objective:
After successful completion of the first year of Masters, students coming in third semester/second year will be provided knowledge about multinuclear NMR, ESR spectroscopic techniques which they had not learned in their entire academic career. Apart from that they will gain understanding into the bioinorganic chemistry, environmental, thermogravimetric and important analytical techniques.

Course Outcome:

CO-1. This semester deals with the some brief glimpses of bioinorganic and detailed investigation of multi-nuclear nuclear magnetic resonance (NMR) for diamagnetic compounds comprising of ^{19}F, ^{31}P, ^{119}Sn, ^{195}Pt and some other nuclei and Electron Spin Resonance (ESR) studies of paramagnetic compounds.

CO-2. Additionally, students get knowledge about the various pollutants existing in nature and their plausible solutions to cope with.

CO-3. After completing this semester the students are supposed to have some expertise in dealing with the multinuclear NMR and ESR.

CO-4. Also, they may get motivated to have inclination towards the bioinorganic chemistry in the next semester.

Unit I

Applications of Spectroscopy

Electron Spin Resonance Spectroscopy

Hyperfine Coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as PH_4, F_2 and $[BH_3]^-$.

Unit II

Nuclear Magnetic Resonance Spectroscopy

Applications of multinuclear NMR with emphasis on **^{11}B,** ^{19}F, ^{31}P, ^{125}Te ^{119}Sn, and ^{195}Pt NMR.

Mössbauer Spectroscopy

Basic Principles, spectral parameters and spectrum display. Application of the technique to the studies of (a) bonding and structures of $Fe^{+2}$and Fe^{+3}compounds including those of intermediate spin, (b) Sn^{+2} and Sn^{+4} compounds ï nature of M-L bond, coordination number, structure and (c) detection of oxidation state and in equivalent MB atoms.

Unit III

Bioinorganic Chemistry

Metal Ions in Biological Systems

(a) Essential and trace metals.
(b) Na^+/K^+Pump.
(c) Vitamin B12, methyl cobalamine, Biomethylation.
(d) Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemoerythrin, model synthetic complexes of iron, cobalt and copper

Electron Transfer in Biology

Structure and function of metalloproteins in electron transport processes-cytochromes and ion sulphur proteins, synthetic models.

Nitrogenase

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Unit IV

Environmental Chemistry: Inorganic Pollutants

a. Aquatic pollution: water quality parameters viz. dissolved oxygen, biochemical oxygen demand, heavy metals Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-} contents.

b. Soil pollution (including agricultural, viz. pesticides, fertilizers, plastics and metals), Waste treatment.

c. Industrial pollution, viz. cement, sugar, distillery, drug, paper and pulp.
d. Nuclear waste management.

Unit V

Selected Topics

a. Chemistry of less familiar metals: Os, Ir, Ru, Rh, Pd
b. Platinium phosphine complexes
c. General method of preparation and important reactions (insertion reactions, metathetical reactions, Lewis acid-base reactions, reactions with protic compounds) of metal and metalloid amides.
d. Preparation of important radio isotopes ($_1H^3$, $_6C^{14}$, $_{11}Na^{22}$, $_{15}P^{32}$, $_{16}S^{35}$) and applications of coordination compounds of Tc^{99}as imaging agents in Nuclear Medicine
e. Principle, instrumentation and applications of TGA and DTA Ion exchange-preparation, mechanism, of exchange capacity of ion exchangers, Principle and applications of photometric and colorimetric techniques in inorganic analysis.

Recommended Books:

1. Physical Methods for Chemistry, R. S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry, E. A. V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Norwood.
4. Practical NMR Spectroscopy, M.L. Martin, J. J. Delpeuch and G. J. Martin, Heyden.
5. Principles of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg, University Science Books
6. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, University Science Books.
7. Inorganic Biochemistry volume I and II. ed. G. L. Eichhorn, Elsevier
8. Fundamentals of analytical Chemistry, D. A. Skoog, D. M. West and F. J. Holler.

Semester III Syllabus

Core Course
Paper Code CHCC-302: Organic Chemistry

Credits:04 **Hours 60**

Course Objective:

After successful completion of the first year of Masters, students coming in third semester/second year in this core course students will be provided knowledge about NMR, ESR spectroscopic techniques and mass spectrometry. Additionally, they will gain understanding into the photochemical reactions, bioorganic chemistry and enzyme catalysis.

Course Outcome:

After the completion of the course the students will acquire knowledge of:

CO-1: nuclear magnetic resonance spectroscopic and mass spectrometry techniques for organic structure elucidation of organic molecules.
CO-2: basics of photochemical reactions of alkenes, carbonyl and aromatic compounds.
CO-3: the fundamental properties and reactivity of biologically important carbohydrates molecules.
CO-4: mechanism of action of enzymes, enzyme catalysed reactions, enzyme models and applications of enzymes.

Unit I

Nuclear Magnetic Resonance Spectroscopy

General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides &mercapto), chemical exchange, effect of deuteration,

factor influencing coupling constant ó Spin decoupling, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE).
FT NMR, advantage of FT NMR, use of NMR in medical diagnostics.

Unit II

Two dimension NMR spectroscopy

Introduction to COSY and DEPT techniques.

Electron Spin Resonance Spectroscopy

Basic principles, zero field splitting and Kramers degeneracy, factor affecting the ñ value. Isotopic and anisotopic hyperfine coupling constant, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications.

Nuclear quadrupole resonance spectroscopy

Quadrupole nuclei, quadrupole moments, electric field gradient , coupling constant, splitting.

Carbon-13 NMR Spectroscopy

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants.

Unit III

Mass Spectrometry

Introduction, ion production ï El, Cl, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometery. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Unit IV

Photochemistry

Photochemistry of Alkenes

Intramolecular reactions of the olefinic bond ï geometrical isomerism, cyclisation reactions, rearrangement of 1, 4 - and 1, 5 ï dienes.

Photochemistry of Carbonyl Compounds

Intramolecular reactions of carbonyl compounds ï saturated, cyclic and acyclic, □, □-unsaturated and □,□-unsaturated compounds. Cyclohexadienones. Intermolecular cyloaddition reactions ï dimerisations and oxetane formation.

Unit V

Bioorganic Chemistry

Enzymes

Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition. Co-enzymes (NAD+, NADP+, FMN, FAD).

Mechanism of Enzyme Action

Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

Biotechnological Applications of Enzymes

Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity, application of immobilized enzymes, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

Recommended books:

1. Organic Photochemistry: A visual approach, Jan Kopecky, VCH publishers (1992).
2. Oganic Photochemistry, O. Kan, McGraw-Hill Inc., US.
3. Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press).

4. Fundamentals of Photochemistry, KK Rohatagi, New Age International (P) Limited.
5. Bioorganic, Bioinorganic and Supramolecular Chemistry, P.S. Kalsi, New Age International (P) Limited.
6. Principles of Molecular Photochemistry, Nicholas J. Turro, V. Ramamurthy J. C., Viva Books.

Semester III Syllabus
Core Course
Paper Code CHCC-303: Physical Chemistry

Credits 04 **Hours 60**

Course Objective:
After successful completion of the first year of Masters, students coming in third semester/second year the objectives of this course is to provide knowledge about theoretical concepts of magnetism, theories of solid state reactions and biopolymers

Course Outcome:
Students will gain knowledge in
CO-1. basic theories and kinetics of solid state reactions.
CO-2. perfect and imperfect crystals and their defects. They will also gain the knowledge of electronic properties and band theory.
CO-3. the quantum theory of paramagnetism, hysteresis.
CO-4. the electrically conducting solids and new superconductors
CO-5. how to determine reaction mechanism and what is the gas phase photolysis.
CO-6. the experimental techniques and photo chemical processes.
CO-7. the biopolymers, their interactions, their thermodynamics and their molecular weight determination.
CO-8. the bioenergetics and statistical mechanics in biopolymers.
CO-9. the structure and function of cell membrane, transport of ions and applications of diffraction methods

Unit I

Solid State Reactions

General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

Crystal Defects and Non-Stoichiometry

Perfect and imperfect crystals, intrinsic and extrinsic defects ï point defects, line and plane defects, vacancies, Schottky and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centers, non-stoichiometry and defects.

Unit II

Electronic Properties and Band Theory

Metals, insulators and semiconductors, electronic structure of solids-band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors. Optical Properties ï Optical reflectance, photoconduction.

Magnetic Properties

Classification of materials: Quantum theory of paramagnetic- cooperative phenomenal magnetic domains, hysteresis.

Organic Solids

Electrically conducting solids, organic charge transfer complex, organic metals, new superconductors.

Unit III

Energy States of Molecules

Franck ï Condon Principle, Physical properties of excited molecules such as refractive index, pKa values and dipole moment. Light emission and chemical reaction from excited states, radiationless deactivation of excited states.

Determination of Reaction Mechanism

Classification, rate constants and life times of reactive energy states ï determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions ï photo-dissociation, gas-phase photolysis.

Photochemical Process and experimental techniques

Photo-reduction, Photo-oxidation, Electron transfer reactions, Photoconduction, Chemiluminiscence, Atom sensitized reactions, sensitization and quenching, Photosensitization, Stern ï Volmer equation. Photosynthesis, Photomorphogenesis and Photochemistry of vision. Spectrometry, Actinometry, Flash Photolysis and Laser Beam.

Unit IV

Biopolymers

Evaluation of size, shape, molecular weight and extent of hydration of biopolymers by various experimental techniques electrophoresis

Statistical Mechanics in Biopolymers

Chain configuration of macromolecules, statistical distribution end to end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem.

Unit V

Biopolymer Interactions

Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibria and various types of binding processes in biological systems.

Thermodynamics of Biopolymer Solutions

Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium muscular contraction and energy generation in mechanochemical system.

Cell Membrane and Transport of Ions

Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamic treatment of membrane transport. Nerve conduction.

Recommended Books:

1. Solid Sate Chemistry and its Application, A. R. West, Plenum
2. Principal Of The Solid state, H. V. Keer, Wiley Eastern.
3. Solid Sate Chemistry, N.B. Hannay.
4. Solid Sate Chemistry, D.K. Chakrabarty, New age Intenational.
5. Fundamental of Photochemistry,K. K. Rohtagi-Mukherji, , Wiley Eastern.
6. Essential Of Molecular Chemistry, A. Gilbert and J, Baggot, Blackwe II.
7. Molecular photochemistry, N. J. Turro, W. A. Benjamin.
8. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
9. Photochemistry, R. P. Kundalland A. Gilbert, Thomson Nelson.
10. Organic photochemistry, J.Coxon and B. Halten, Cambridge University Press.
11. Principles of Biochemistry, A. L. Lehninger, Worth publisher.
12. Biochemistry, L. Stryer, W.H. Freeman.
13. Biochemistry, J David Rawn, Neil Patterson.
14. Biochemistry, Voet and Voet, John Wiley.
15. Outlines of Biochemistry, E. E. Conn and P.K. Stumpf, John Wiley.
16. Bioinorganic Chemistry: A Chemical Approach to Enzyme action, H. Dugas and Penny, Springer-Verlag
17. Macromolecules: Structure and Function, F. Wold, Prentice Hall.

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Semester III Syllabus
Core Course
Paper Code CHCC-304: Advanced Chemistry Practical Credits 4

Course Objective:
After successful completion of the first year of Masters, students coming in third semester will be provided experimental knowledge about the separation and the quantitative analyses using gravimetric and volumetric methods. Different analytical techniques in organic chemistry, practical knowledge of surface chemistry and colligative properties.

Course Outcome:
In order to make students understand the theories taught to them in M.Sc. semester (III) indifferent branches of chemistry e.g. Inorganic, Organic and Physical, the followingpracticals are introduced .Students will learn:

CO-1. Gravimetric estimation of complex mixture involving two or three constituents and analysis of alloys and minerals.
CO-2. Volumetric estimations and various titrations
CO-3. Qualitative analysis, acetylation method, saponification value and extraction of organic compounds.
CO-4. The basic knowledge like preparation of solution, standardization of secondarysolution, dilution, calibration, and handling of some sophisticated electronic relatedto the practical syllabus.
CO-5. Freundlich Absorption Isotherm, enthalpy, molecular weight determinations by elevation in boiling point method, depression in freezing point method and
viscosity method, surface tension, molecular energy and Parachor of given liquid.
CO-6. To focus their aim for future prospects of Ph.Dprogramme and pharmaceuticalindustry

INORGANIC CHEMISTRY

1. Gravimetric estimations of complex mixtures involving two or three constituents, Analysis of alloys and minerals.
2. Volumetric estimations:
   i. EDTA titrations - Determination of Zn, Ca, Mg and Fe. Hardness of water.
   ii. $KBrO_3$ and KIO_3 titrations ï Determination of As_2O_3 and $[Fe(CN)_6]^{4-}$.
   iii. Chloramine T ï titrations - Determination of NO_2 in a sample.
   iv. Ceric Ammonium Sulphate titrations - Determination of Fe and organic acids.

ORGANIC CHEMISTRY
Quantitative analysis
Major Experiments-
Determination of percentage or number of hydroxyl group in an organic compound by acetylation method.
Estimation of amines/phenols using bromate bromide solution/or acetylation method.
Determination of iodine and saponification value of an oil sample.
Minor Experiment-
Extraction of organic compounds.

PHYSICAL CHEMISTRY
General Experiments.

1. To verify Freundlich Adsorption Isotherm.
2. To determine enthalpy of given salt solution.
3. To determine molecular weight of a given electrolyte by elevation in boiling point method (Landsbigger method) and also find out its van't Hoff factor.
4. Determine molecular weight of a given polymer by viscosity method.
5. Find out surface tension, molecular energy and Parachor of given liquid at room temperature.
6. Determine molecular weight of a given electrolyte by depression in freezing point method.

Kinetics Experiments:

7. Study reaction kinetics between KI and $K_2S_2O_8$ by fractional change method and find out its order of reaction at a given temperature.
8. Study reaction kinetics between acetone and iodine by isolation method and determine its order of reaction at a given temperature.

Recommended Book:

1. Vogels Text book of Quantitative Analysis revised, J. Bessett, R.C. Denney, G.H. Jellery and J. Mendhan ELBS
2. Experimental Inorganic Chemistry by Mounir A, Malati, Horwood series in Chemical Science (Horwood publishing Chichester) 1999.
3. Inorganic Experiments, J. Derexwoolings VCH
4. Microscale Inorganic Chemistry, Z. Scafran, R.M. Pike and M.M. Singh Wiley.
5. Practical Inorganic Chemistry, G. Marrand, B.W. Rockett, Van Nostrand.
6. The systematic Indentification of Organic Compounds, R.L. Shringer and D.Y. Curlin.
7. Qualitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
8. Basic concept of Analysis chemistry, S.M. Chopkar, Wiley Bastern.
9. Synthesis and characterization of Inorganic compounds, W.L. Jolly, Prentice Hall.
10. Systematic Qualitative Organic Analysis, H. Middeton, AdwardArnoid.
11. Handbook of Organic Analysis Qualitative and Quantitative, H. Clark, Adward Ar.
12. Vogelôs Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
13. Practical Physical Chemistry, A.M. James and F.E. Prichand, Longman.
14. Findleyôs Practical Physical Chemistry revised, B.P. Levitt, Longman.
15. Experimental Physical Chemistry, R.C. Das and Bebera, Tata Mc Grawhill.
16. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Barg (R. Chand and Co., Delhi)
17. Experimental Physical Chemistry by D.P. Shoemaker Mc Grawhill, 7th Edition 2003.
18. Experiments in Chemistry, D.V. Jahagirdar, Himalaya Publishing House.
19. Practical Physical Chemistry, B. Vishwanathan and P.S. Raghwan, Viva Books.
20. General Chemistry Experiments, Anil J Elias, University Press (2002)
21. Experimental Physical Chemistry, V.D. Athawale, ParulMathur, New Age International (P) Limited.
22. Systematic Experiment in chemistry, ArunSethi, New Age International (P) Limited.
23. Experiments in Physical chemistry, J.C. Ghosh, BharatiBhavan.
24. Advanced Practical Physical Chemistry, JB Yadav.
25. Practical Organic Chemistry, Mann and Saunders.

Semester III Syllabus

Elective (Non-Credited)
Paper Code CHEL-301A: Environmental Chemistry

Credits 00 **Hours 60**

Course Objective:

After successful completion of the first year of Masters, students coming in third semester/second year and the objectives of this course are to provide knowledge about environmental chemistry and methods of analyses for the estimation of myriad of pollutants coming from domestic and industries.

Course Outcome

CO-1. Environmental chemistry is an interdisciplinary science that includes atmospheric, aquatic and soil chemistry, as well as heavily relying on analytical chemistry and being related to environmental and other areas of science.

CO-2. By the knowledge of this paper student will understand the fate of chemical species in the air, soil, and water environments the effects of human activity and biological activity on these.

CO-3. They will also be able to grasp the knowledge of industrial pollution and environmental toxicology.

Unit I

Environment

Introduction, Composition of atmosphere, Vertical temperature, heat budget of the earth atmospheric system, vertical stability atmosphere. Biogeochemical cycles of C,N,P,S and O. Bio distribution of elements.

Unit II

Hydrosphere

Chemical Composition of Water bodies- lakes, streams river and wet lands etc, hydrological cycle.

Aquatic Pollution :- Inorganic, Organic, Pesticide, Agricultural, Industrial and Sewage, detergents, oil spills and oil pollutants, Water quality parameters-dissolved oxygen, biochemical oxygen demands, solids metals, content of chloride, Sulphate, phosphate, nitrate and micro-organisms water quality standards.

Unit III

Analytical methods for measuring BOD, DO, COD, F, Oil, Metals (As, Cd, Cr, Hg, Pb, Se etc) residual chloride and chlorine demand, Purification and treatment of water.

Soil

Composition, micro and macro nutrients, Pollution- fertilizers, pesticides, plastics and metals, waste treatment.

Unit IV

Atmosphere:- Chemical Composition of atmosphere, Particles, Ions and radicals and their formation chemical and photochemical reaction in atmosphere smog formation, oxides of N,C,S,O and their effect, pollution by chemicals, petroleum, minerals, ChloroFluoro hydrocarbons. Green house effect, acid rain, air pollution controls and their chemistry.

Analytical methods for measuring air pollutants, continuous monitoring instruments,

Unit V

Industrial Pollution

Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy, polymers, drugs etc. Radionuclide analysis, Disposal of Wastes and their management.

Environmental Toxicology

Chemical solution to environmental problems, biodegradability, principles of decomposition, better industrial processes.

Recommended Books:

1. Manahan, Stanley E. Fundamentals of Environmental Chemistry Boca Raton: CRC Press LLC, 2001
2. Sonja Krause, Herbert M. Clark, James P. Ferris, Robert L. Strong Chemistry of the Environment, Elsevier Science & Technology Books 2002
3. Eugene R. Weiner Applications of Environmental Chemistry 2000 CRC Press, LLC
4. By Clair, N. Sawyer, Perry L. Mc Carty, Gene F. Parking Chemistry for environmental engineering and Science (5^{th}edition) McGraw Hill Professional.

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Semester III Syllabus
Elective (Non-Credited)
Paper Code CHEL-301B: Chemistry of Natural Products

Credits 00 **Hours 60**

Course Objective:
After successful completion of the first year of Masters, students coming in third semester/second year and the objectives of this course are to provide knowledge about classification, syntheses and properties of varied type of natural products.

Course Outcome:
After the completion of the course the students will acquire knowledge of:
CO-1. Classification, stereochemistry and synthesis of some important terpenoids and carotenoids.
CO-2. Nomenclature, structure elucidation, physiological action and synthesis of Alkaloids.
CO-3. Occurence, basic structure, Isolation and synthesis of some prominent Steroids.
CO-4. Types of carbohydrates, structure elucidation, biological importance and Blood sugar.
CO-5. Types of plant pigments, their structure determination, isolation and synthesis of some significant plant pigments.

Unit I

Terpenoids and Carotenoids
Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.
Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol, Ŭ-Terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and ɓ-Carotene.

Unit II

Alkaloids
Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, roe of alkaloids in plants.
Structure, stereochemistry, synthesis and biosynthesis of the following : Ephedrine, (+)- Coniine, Nicotine, Atropine, Quinine and Morphine.

Unit III

Steroids
Occurrence, Nomenclature, basic skeleton, Dielŝ hydrocarbon and stereochemistry. Isolation, Structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Biosynthesis of steroids.

Unit IV

Carboydrates
Structure, function, configuration & conformation of important derivatives of monosaccharides & glycosides; disaccharides (lactose, maltose and sucrose); Polysaccharides ï structural polysaccharide (cellulose, chitin); storage polysaccharides (starch and glycogen).
Role of sugars in biological recognition.
Blood group determinants.

Unit V

Plant Pigments
Occurence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Luteolin, Quercetin, Myrcetin, Quercetin 3-glucoside, Cyanidin, Hirsutidine.

Recommended Books:

1. Natural Products: Chemistry and Biological, J. Mann. R.S. Davidson, J.B, Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Essex.
2. Organic Chemistry, Vol 2, I.L. Finar, ELBS.
3. Stereoselective Synthesis: A Practical Approach, M. Nogradi, VCH.
4. Roddŝ Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
5. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic publishers.

6. Introduction to flavonoids, B.A. Bohm, Harwood Academic Publishers.
7. New Trends in Natural product Chemistry, Atta-ur-Rahman And M.I. Choudhary, Harwood Academic Publishers.
8. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.

M.Sc. Chemistry Semester III Syllabus
Summer Internship
Paper Code CHIN-301: Summer Internship

Credits 04

Course Objective:

After successful completion of the first year of Masters, students coming in third semester/second year will be provided exposure of 3-4 months in any Pharmaceutical or Scientific laboratory which will boost-up the moral of Masters students to work in a competitive environment and will groom their mind-set to become ñ***ATMANIRBHAR"***

Course Outcome:

CO-1. To learn the procedure of identifying, approaching, applying and getting approval of internship from pharmaceutical companies.
CO-2. To witness the entire work area of the pharmaceuticals.
CO-3. To understand the nature of job.
CO-4. To identify the RD procedures and technical skills involved.
CO-5. To understand the complete mechanism of the reactions involved in the manufacturing areas at different sectors.
CO-6. To correlate the manufacturing procedures with simple laboratory synthesis.
CO-7. To learn the environment aspects, pollution, their control involved in the manufacturing unit.
CO-8. To prepare a final evaluation report and presentation for the internship carried out for 90 to 100 days.

3-4 Months training in any Pharmaceutical or Scientific laboratory. After the completion of training project report will be submitted, followed by its evaluation by presentation & viva-voce examination.

Semester-III Syllabus
Interdepartmental
Paper Code CHIER-301: Concepts of Chemistry

Credits 4 **Hours 60**

Course Objective:

After successful completion of the first year of Masters, students coming in third semester/second year and the objectives of this course are to provide knowledge to the students from other faculties about the fundamental of chemistry.

Course Outcome:

After the completion of the course the students will acquire the knowledge of:

CO-1. Use of arrow notations in Organic reactions mechanism, different kinds of polymer and their importance, different techniques of polymerization, each quantum number represents and how to obtain quantum numbers for any electron in an atom and determine the number of protons, neutrons, electrons and nuclei in elements and compounds.
CO-2. Periodic properties of all the elements, electronegativity and whether a bond is metallic, ionic, covalent or polar covalent.
CO-3. Predict atomic structure, chemical bonding or molecular geometry based on accepted models
CO-4. Electronic effects operates in covalent bonds, Types of Reactions and different types of Intermediates formed during the reactions

CO-5. Appropriate method of solution for a variety of Mathematic problems, basic physical quantities and various gas Laws for observation of behaviour of gas and Kinetic molecular model.

Unit I

Types of arrows used in Organic Reaction Mechanism ï Curved arrow, half- headed and double headed arrows

Introduction of Polymers, natural and synthetic polymers, properties of polymers, Biomedical polymers and their importance

Quantum numbers. Zeeman effect. Pauliôs exclusion principle. Aufbau principle. Effective nuclear charge, screening effect, Slaterôs rule- applications and limitations

Unit II

Classification of Elements and Periodicity of Properties, noble gases and s, p, d and f- block elements. Modern periodic teble. Position of hydrogen in the periodic table. Horizontal, vertical and diagonal relationships in the periodic table. Scales of electronegativity- Pauling, Mulliken and Allred Rochow scale.

Ionic bond ï factors influencing the formation of ionic compounds ï ionization energy, electron affinity and lattice energy; inert pair effect, Fajanôs rules. Covalent bond ï polarity of covalent bond.

Unit III

Valence bond theory (VBT) ï sigma and pi bonds, hybridization, valence shell electron pair repulsion (VSEPR) theory and geometries of molecules ï $BeCl_2$, H_2O, BF_3, NH_3, XeF_4, BrF_3, PCl_5, SF_6 and IF_7.

Molecularorbital theory (MOT) ï bonding and antibonding orbitals, bond order, applications of MOT to H_2, He_2, N_2, O_2, O_2^+, O_2^-, HF and CO. Comparison between VBT and MOT.

Unit IV

Resonance and Inductive effect

Reaction Intermediates ï Homolytic and Heterolytic bond breaking (carbonium ion, carbanion and free radical)

Types of Reactions ï Addition, Elimination, Substitution and Rearrangement Reactions.

Unit V

Mathematical concepts:

Logarithm, anti-logarithm, functions, integrations and differentiation, partial differentiation, trigonometric functions, exponential functions, binary and decimal numbers.

Basics of physical chemistry:

Physical quantities- moles, mole fraction, normality, molality, molarity, formality, equivalent weight, molecular weight and their determination, SI units and derived units.

Kinetic molecular theory:

Ideal and non- ideal gases, laws of gases, the kinetic molecular model, expressions for the pressure of gas, molecular velocities and their relations, mean free path, collision diameter, collision number.

Recommended Books:

1. Inorganic Chemistry, Puri, Sharma, Kalia and Kaushal.
2. Pradeep's Inorganic Chemistry, K. K. Bhasin, Pradeep Publication.
3. Chemistry for Degree Students, R. L. Madan, S. Chand Publishing.
4. Organic Chemistry, M. K. Jain, Shoban Lal & Co.
5. Pradeep's Organic Chemistry, S. N. Dhawan, Pradeep Publication.
6. Physical Chemistry, Puri Sharma &Pathania.
7. Pradeep Physical Chemistry, Khetrapal, Pradeep Publication.

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