DETAILED CURRICULUM

of

Master of Science in Chemistry
(M.Sc. Chemistry)

Analytical Chemistry & Organic Chemistry

School of Science

GSFC UNIVERSITY
EDUCATION RE-ENVISIONED

1st Year

Semester – I

Total Credits = 26 **Total Marks: 650**

Objectives: *The student can recognize and recall relevant knowledge from*

- *fundamentals of chemical analysis*
- *basics of Analytical, organic, inorganic and physical chemistry*

Sr. No.	Course Code	Course Title	*L*	*T*	*P*	C	Marks
Theory Courses							
1.	MSCM101	Analytical Chemistry – I	*4*	*0*	*2*	**6**	150
2.	MSCM102	Organic Chemistry – I	*4*	*0*	*2*	**6**	150
3.	MSCM103	Physical Chemistry –I	*4*	*0*	*2*	**6**	150
4.	MSCM104	Inorganic Chemistry – I	*4*	*0*	*2*	**6**	150
5.	MSCM105	Internship - I	*0*	*0*	*0*	**2**	50

Semester – II

Total Credits = 26 **Total Marks: 650**

Objectives: *The student can understand the core concepts of*

- *analytical instrumentation and its application in separation techniques*
- *different reaction mechanisms*
- *chemical kinetics, fundamentals of surfactants and its applications*
- *polymers and nuclear chemistry*
- *chemical bonding and theories related to it*
- *fundamental of spectroscopy*
- *computer applications in sciences*
- *research methodology and scientific communication*

Sr. No.	Course Code	Course Title	*L*	*T*	*P*	C	Marks
Theory Courses							
1.	MSCM201	Analytical Chemistry – II	*4*	*0*	*2*	**6**	150
2.	MSCM202	Organic Chemistry – II	*4*	*0*	*2*	**6**	150
3.	MSCM203	Physical Chemistry – II	*4*	*0*	*2*	**6**	150
4.	MSCM204	Inorganic Chemistry – II	*4*	*0*	*2*	**6**	150
5.	MSCM205	Internship - II	*0*	*0*	*0*	**2**	50

2nd Year (Analytical Chemistry)

Semester – III **Total Credits: 24** **Total Marks: 600**

Objectives: *The student can use technological concepts:*

- *of chemical instrumentation and its applications*
- *to analyse instrumental data for solving chemical problems*
- *to have effective skill to make informed and responsible decision that lead to resolve the analytical chemistry challenges*
- *of Medicinal Chemistry, Environmental Chemistry and Green Chemistry through electives*

Sr. No.	Course Code	Course Title	*L*	*T*	*P*	*C*	Marks
Theory Courses							
1.	MSCM301	Analytical Chemistry – III	*4*	*0*	*2*	**6**	150
2.	MSCM302	Analytical Chemistry – IV	*4*	*0*	*2*	**6**	150
3.	MSCM303	Analytical Chemistry – V	*4*	*0*	*2*	**6**	150
4.	MSCM304	Elective - I	*3*	*0*	*1*	**4**	100
5.	MSCM305		*4*	*0*	*0*		
6.	MSCM306	Internship-III	*0*	*0*	*0*	*2*	50

MSCH304: *Computer Application in Chemistry*

MSCH305: *Research Methodology*

Semester – IV **Total Credits: 24** **Total Marks: 550**

Objectives: *The student can:*

- *distinguish between parts, relate them each other to formulize overall structure and purpose*
- *make judgment and justify decisions related to analytical chemistry*
- *put elements together to form whole function and create a new product or point of view related to chemical analysis*
- *acquire the skills for identifying and solving analytical problems via the conducting of research project*

Sr. No.	Course Code	Course Title	*L*	*T*	*P*	**C**	Marks
Theory Courses							
1.	MSCM401	Analytical Chemistry – VI	*4*	*0*	*0*	**4**	100
2.	MSCM402	Analytical Chemistry – VII	*4*	*0*	*0*	**4**	100
3.	MSCM403	Analytical Chemistry – VIII	*4*	*0*	*0*	**4**	100
4.	MSCM404	Elective	*4*	*0*	*0*	*4*	100
	MSCM405		*4*	*0*	*0*		
	MSCM406						
5.	MSCM407	Dissertation/ Practical	*0*	*2*	*4*	*6*	100
6.	MSCM408	Comprehensive Viva – voce	*0*	*2*	*0*	*2*	50

MSCH404: Analysis and Characterization of Polymers

MSCH405: Analytical Chemistry-IX

MSCH406: Environmental Analytical Chemistry

2nd Year (Organic Chemistry)

Semester – III							**Total Credits: 24**	**Total Marks: 650**
Objectives: *The student can use technological concepts:* • *of organic spectroscopy and their application* • *to design organic reactions* • *to have effective skill to make informed and responsible decision that lead to organic synthetic challenges* • *of Medicinal Chemistry, Environmental Chemistry and Green Chemistry through electives*								
Sr. No.	**Course Code**	**Course Title**	*L*	*T*	*P*	**C**	Marks	
Theory Courses								
1.	MSCM301	Organic Chemistry – III	*4*	*0*	*2*	**6**	150	
2.	MSCM302	Organic Chemistry – IV	*4*	*0*	*2*	**6**	150	
3.	MSCM303	Organic Chemistry – V	*4*	*0*	*2*	**6**	150	
4.	MSCM304	Elective - I	*3*	*0*	*1*	**4**	100	
5.	MSCM305		*4*	*0*	*0*			
6.	MSCM306	Internship -III	*0*	*0*	*0*	*2*	50	
MSCH304: *Computer Application in Chemistry*								
MSCH305: *Research Methodology*								

Semester – IV							**Total Credits: 24**	**Total Marks: 550**
Objectives: *The student can:* • *distinguish between parts, relate them each other to formalize overall structure and purpose* • *make judgment and justify decisions related to environmental organic chemistry* • *put elements together to form whole function and create a new product or point of view* • *acquire the skills for identifying and solving organic chemistry problems via the conducting of research project*								
Sr. No.	**Course Code**	**Course Title**	*L*	*T*	*P*	**C**		
Theory Courses								
1.	MSCM401	Organic Chemistry – VI	*4*	*0*	*0*	**4**	100	
2.	MSCM402	Organic Chemistry – VII	*4*	*0*	*0*	**4**	100	
3.	MSCM403	Organic Chemistry –VIII	*4*	*0*	*0*	**4**	100	
4.	MSCM404 MSCM405 MSCM406	Elective- II	*4*	*0*	*0*	*4*	100	
5.	MSCM407	Dissertation/Practical	*0*	*2*	*4*	*6*	100	
6.	MSCM408	Comprehensive Viva – voce	*0*	*2*	*0*	*2*	50	
MSCH404: Analysis and Characterization of Polymers								
MSCH405: *Organic Chemistry – IX*								
MSCH406: Environmental Analytical Chemistry								

First Year (Analytical Chemistry & Organic Chemistry)

Semester - I

Course Code:	MSCM101	L	T	P	**Credits**
Course Name:	Analytical Chemistry – I	4	0	2	**6**

Theory

Course Outline:

The course deals with the basic analytical methods and offers sound knowledge of chemistry involved in an analysis and to understand the concept of analytical techniques. In the beginning of the course it discusses the errors, accuracy and precision of data and the significance of various tests. It also describes the general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. The most important Job's method of continuous variation is elaborately discussed.

Aim of the Course:

After completing this course student will be able to:

- *learn the basic analytical methods and have a sound knowledge of chemistry involved in an analysis.*
- *understand the concept of analytical techniques.*

Unit – I Language of Analytical Chemistry: Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedure and protocol). Data Handling Spreadsheet in Analytical Chemistry: Accuracy and Precision, determinate error, Independent errors, Significant numbers, expressing accuracy, standard deviations, propagation of errors, confidence limits. Rejection of results and problems. Standardization and Calibration: Analytical samples and methods of sampling, sample handling, gross sample, preparation of laboratory samples, automated sample handling comparison with standards numerical problems.

Unit – II Calculations based on chemical principles: The following topics are to be covered in the form of numerical problems only: concentration of a solution based on volume and mass units, calculations of ppm, ppb and dilution of the solutions, concepts of mol, stoichiometry of chemical reactions, concepts of kg mol, limiting reactant, theoretical and practical yield, solubility and solubility equilibria, effect of presence of common ion, calculations of pH of acids, bases acidic and basic buffers, concept of formation constants, stability and instability constants, stepwise formation constants, oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing, and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a solution of a oxidizing /reducing agent and its relationship with molarity).

Unit – III Spectroscopic Methods: Recapitulation of basic concepts, electromagnetic spectrum, sources, detectors.

Sample containers, laser as source of radiation, fibre optics, Introduction of Fourier Transform.

Molecular Spectroscopy-Ultraviolet and Visible Spectroscopy (Numericals). Derivation of Beer-Lambert's Law and its limitations, factors affecting molecular spectroscopy-temperature, solvent and effect of substituents on charge transfer bands. Applications of Ultraviolet and Visible spectroscopy: Simultaneous spectroscopy, derivative spectroscopy.

Infrared Absorption Spectroscopy: Instrumentation sources, sample handling, transducers, dispersive, non - dispersive instrument. FTIR and its advantages, applications of IR: Qualitative

with emphasis on "Finger Print" region, Quantitative analysis, Advantages and Limitations of IR., Introduction and basic principles of diffuse reflectance spectroscopy and attenuated total reflectance Spectroscopy.

Unit - IV Thermal methods: Introduction, recapitulation of types of thermal methods, comparison between TGA and DTA. Differential Scanning Calorimetry – Principle, comparison of DTA and DSC, Instrumentation, block diagram, nature of DSC curve, factors affecting curves (Sample size, sample shape, pressure). Determination of heat of reaction, specific heat, percentage crystallinity, magnetic transition, oxidative stability, Applications-Analysis of drug analysis.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self-study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education
2. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 1.
3. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004, Ch: 5.
4. Undergraduate Instrumental Analysis, 6th Edition, J W Robinson, Marcel Dekker, Ch:1.
5. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Chapter: 3 & 4) (Free download).
6. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5th Edition, Harcourt Asia Publisher.
7. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6th Edition, CBS Publisher.
8. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher Environmental Health and Safety Publications. OECD. 1. 1998.
9. 3000 solved problems in chemistry, Schaums Solved problem series, David E. Goldbers, Mc Graw Hill international Editions, Chapter 11,15,16,21,22
10. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. Graw Hill (1987)
11. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman
12. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12

Practical
Course Outline: It includes the analysis of mixture of $CoSO_4$ and $NiSO_4$, determination of dissociation constant, determination of metal concentration using spectrophotometry. In addition it also discusses how to determine BOD, COD and DO of effluent sample

1. Analysis of mixture of $CoSO_4$ and $NiSO_4$
2. pH – indicator – Dissociation constant
3. Determination of Cu(II) by Spectrophotometric titiration.
4. Determination of purity of vanillin by conductometry.
5. Assay of aspirin tablet by potentiometry
6. Analysis of oils (Edible Oil and Engine Oil).
7. Determination of COD of effluent sample.

8. Determination of DO of effluent sample.
9. Determination of BOD of effluent sample.
10. Moisture by Karl – Fischer.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM102	L	T	P	**Credits**
Course Name:	Organic Chemistry –I	4	0	2	**6**

Theory

Course Outline:

This course describes the effects of structure of molecule on reactivity and explains the concept of aromaticity using Huckel Rule. In addition it discusses optical activity in the absence of a chiral carbon. Most importantly LFER using Hammett-Taft equation is discussed. It also describes the NGA, protection and deprotection of functional group and asymmetric synthesis in detail.

Aim of the Course:

After completing this course student will be able to:

- *understand the effects of structure of molecule in reactivity.*
- *explain the concept of aromaticity.*
- *understand the concept of asymmetric synthesis.*

Unit – I Structure and reactivity: Chemical bonding and basis of reactivity- Chemical bond, delocalization, conjugation, resonance, hyperconjugation, tautomerism, inductive effects, MOT and VBT approach. Bonding other than covalent bonding: Ionic, hydrogen bond, inclusion compounds, rotaxanes, catenanes, cyclodextrins, cryptands, fullerenes, crown ethers. Acidity and basicity: various structural effects, hard and soft acid and base concept.
Aromaticity: Benzenoid and non-benzenoid compounds, Huckels rule, antiaromaticity, Application to carbocyclic and heterocyclic systems, annulenes, azulenes, and Current concepts of aromaticity. Structure and stability of reactive intermediates, carbenes, nitrenes, carbocations, carbanions and free radicals.

Unit – II Stereochemistry: Sterochemical principles, enantiomeric relationship, distereomeric relationship, R and S, E and Z nomenclature in C, N, S, P containing compounds, Prochiral relationship, stereospecific and stereoselective reactions, optical activity in biphenyls, spiranes, allenes and helical structures. Conformational analysis of cyclic and acyclic compounds.

Unit – III Organic reactions-Substitution reaction, Aliphatic nucleophilic substitution. SN^1, SN^2, SET and SNV mechanism, NGP by pi and sigma bonds, classical and non-classical carbocations, phenonium ions, norbornyl system, carbocation rearrangement in NGP, SN_i mechanism, nucleophilic substitution in allylic,Trigonal and vinylic carbon, effect of structure, nucleophile, leaving group, solvent on rate of SN^1 and SN^2 reactions, ambident nucleophile and regioselectivity. Aromatic Electrophilic substitution. Arenium ion mechanism, orientation and reactivity, energy profile diagram, ortho, para, ipso attack, orientation in other ring systems, naphthalene, anthracene, six and five membered heterocycles, diazonium coupling. Important reactions like Friedel crafts alkylation and acylation, Nitration, halogenation, formylation, chloromethylation, sulponation.

Unit - IV Aromatic nucleophilic substitution- SNAr, SN^1, Benzyne and SNR_1 reactions, reactivity: effect of substrate structure, leaving group and attacking nucleophile. Addition reactions - Addition to C-C multiple bonds - mechanism and stereochemical aspects of addition reaction involving electrophile, nucleophile and free radicals, Regio and chemo selectivity, orientation and reactivity, conjugate addition. Elimination reactions - E_1, E_2, E_{1cb} mechanisms, orientation and stereochemistry in elimination reaction, reactivity effect of structure, attacking and leaving group, competition between elimination and substitution, syn eliminations.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity

and understanding of the basic concepts of subject area.

- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on class room discussion will also be a part of learning activity.

Recommended Books:

1. Organic Chemistry –by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
2. Advanced Organic Chemistry –by J. March 6th Edition
3. Advance Organic Chemistry (part A) –by A. Carey and R.J. Sundberg
4. Stereochemistry of carbon compound-by E.L. Eliel
5. Stereochemistry of organic compound-by Nasipuri
6. Guide book to Reaction Mechanism –Peter Sykes

Practical
Course Outline: It includes the determination of neutralization equivalent of organic acids as well as separation & identification of organic mixtures containing two compounds.

1. Estimation of Phenol and Aniline.
2. Separation & Identification of organic mixtures containing two compounds. (at least three)
3. Two stage Organic preparation(at least four)

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM103	L	T	P	**Credits**
Course Name:	Physical Chemistry –I	4	0	2	**6**

Theory

Course Outline:

This course describes the adsorption, electrochemistry, and statistical thermodynamics in detail. It focuses on the importance of various fundamental concepts of physical chemistry, specifically BET isotherms and its application. Moreover methods for preparation of heterogeneous catalysts, catalyst characterization, important industrial catalysts and phase transfer catalysis are dealt with. In the second part, the phenomenon of electrical double layer is understood. The theoretical models illustrating the electrical double layer viz. parallel plate condenser model, Gouy-Chapmann diffused charge model and Stern model are thoroughly looked into. Other important topics like sweep voltammetry, Cyclic Voltammetry are also discussed. In the last part, basics of statistical thermodynamics are discussed. Mainly the Boltzmann's distribution law, evaluation of β, partition function etc are also discussed there in.

Aim of the Course:

After completing this course student will be able to:

- *understand the importance of various fundamental concepts of physical chemistry.*
- *gain insights into various industrial applications of phenomenon like catalysis and, electrochemistry.*
- *develop understanding of limitations of classical thermodynamics*

Unit – I The Gaseous state & The Kinetic Molecular Theory The gaseous state, General characteristics of gases, The gas laws: Boyle's law, Charles' law, Gay Lussac's law, Avogadro's law, The Ideal-gas equation, Dalton's Topics –Law of Partial Pressures, Graham's law of Diffusion, Assumptions of the Kinetic Molecular Theory of Gases, Statement of Kinetic Gas Equation and the significance of the terms involved in it, Kinetic Gas Equation in terms of Kinetic Energy, Deduction of Gas Laws (Boyle's law, Charles' law, Avogadro's law & Graham's law of diffusion) as well as Ideal gas equation and Dalton's law of Partial Pressures from the Kinetic Gas Equation, Statement of the Maxwell Distribution Law of Molecular Velocities and its explanation, Different types of molecule velocities and their expressions, Collision Properties (Parameters), Transport phenomena viz. viscosity, thermal conductivity and diffusion in gases, Derivation of the different relationships between the mean free path and the coefficients of viscosity, thermal conductivity and the diffusion, Influence of temperature and pressure on coefficients of viscosity, thermal conductivity and diffusion, Degrees of Freedom (rotational and vibrational) and their calculations, Principle of Equipartition of Energy, Numericals.

Unit – II Electromotive Force (EMF) of Galvanic Cells Introduction, Galvanic Cells, Reversible cells, Reversible electrodes, Single electrode potential, Electrical energy in a galvanic cell, Electrical energy and Free energy change of cell reaction, Relation between Electrical energy and Enthalpy of a cell reaction, Determination of ΔH^{o} , ΔG^{o} and ΔS^{o} of a cell reaction, EMF and Equilibrium constant of a cell reaction, Standard EMF and Equilibrium constant, The Nernst equation, Electrode-Concentration Cells, Electrolyte-Concentration Cells, Concentration cells with and without transference, Liquid Junction Potential, Hydrogen electrode, Calomel electrode, Silver-Silver electrode, Glass electrode, Quinhydrone electrode, Applications of EMF measurements, Potentiometric titrations, Acid-Base, Redox and Precipitation titrations, Numericals.

Unit – III Polarography Principle, apparatus and electrodes systems, components of limiting current, residual current, migration current, diffusion current, catalytic current, convention current, adsorption current and kinetic current. Polarographic maxima, half-wave potential, derivation of relationship between half wave potential and diffusion coefficients, fractions governing diffusion current, Calibration curve method, standard addition method, effect of pH on

polarography and applications

Unit – IV Amperometry Principle, apparatus and electrode system. Four different types of amperometric titrations, advantages and disadvantages of amperometry. Applications of amperometry.

pH-metry Introduction, construction and working of different electrodes, Ion selective electrodes, Applications of pH measurements, acid-base titrations, polybasic acid base titrations, determination of dissociation constant of weak acids and weak bases, determination of hydrolysis constant and degree of hydrolysis.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based classroom discussion will also be a part of learning activity.

Recommended Books:

1. Bockris, J. O'M. and Reddy, A. K. N. (1998) Modern Electrochemistry, Vol. 2 A & B, Second Edition, Plenum Press, New York.
2. Chakrabarty, D. K. (Reprint 2007), Adsorption and Catalysis by Solids, New Age International Publishers, New Delhi.
3. Bond, G. C. (1974), Heterogeneous catalysis: Principles and applications Clarendon Press, Oxford
4. Atkins' Physical Chemistry, P. W. Atkins and De Paula, 8th edition (2010).
5. Physical Chemistry, T. Engel and P. Reid, Pearson Education (2006).

Practical
Course Outline: It includes the comparison of acid strengths, determination of energy of activation, distribution coefficient of I_2 between tow immiscible solvents. It also explains the determination of solubility and solubility product of sparingly, soluble salt conductometrically, Conductometric titration of KCl with $AgNO_3$, CMC of surfactant by conductometric method. In addition, this explains the mixture titration using pH metry, pK_1 and pK_2 using pH metry.

1. Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis.
2. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
3. Distribution coefficient of I_2 between tow immiscible solvents.
4. Conductometric titration of a week acid with strong base.
5. Conductometric titration of mixture of weak and strong base.
6. Determination of solubility and solubility product of sparingly soluble salt conductometrically.
7. Conductometric titration of KCl with $AgNO_3$
8. CMC of surfactant by conductometric method.
9. Mixture titration using pH metry.
10. pK_1 and pK_2 using pH metry.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM104	L	T	P	**Credits**
Course Name:	Inorganic Chemistry – I	4	0	2	**6**

Course Outline:

It gives a clear understanding about the inorganic reaction mechanism. It mainly deals with substitution reaction and redox reaction. Redox reaction includes the detailed study of inner sphere, outer sphere mechanisms as well as mixed valence complex. Metal carbonyl and nitrosyls are elaborately included in the course. It also explores some of the organometallic compounds of p-block elements, bioinorganic chemistry and coordination chemistry.

Aim of the Course:

After completing this course student will be able to:

- *understand the concepts of bond formation in a molecule.*
- *acquire knowledge in metal complexes.*
- *understand the importance of metal complexes in nature.*

Unit – I Coordination Chemistry: Concept and scope of ligand fields, free ion configuration, terms and states, energy levels of transition metal ions, free ion terms, term wave functions, spin-orbits coupling. Ligand Field Theory of Coordination complexes, effect of ligand field on energy levels of transition metal ions, weak cubic ligand field effect on Russill Saunders terms, strong field effect, correlation diagrams, Tanabe-Sugano Diagrams, Spin-Pairing energies. Electronic spectra of Transition Metal Complexes. Introduction, band intensities, band energies, band with and shapes, spectra of 1^{st}, 2^{nd} and 3^{rd} row ions and rare earth ion complexes, spectrochemical and nephlauxeetic series, charge transfer and luminescence, spectra, calculations of Dq, B, β parameters.

Unit – II Magnetic Properties of Coordination Complexes: Origin magnetism, types of magnetism, Curie law, Curie-Weiss Law, Magnetic properties of complexes-paramagnetism 1^{st} and 2^{nd} ordered Zeeman effect, quenching of orbital angular momentum by Ligand fields, Magnetic properties of A, E and T ground terms in complexes, spin free spin paired equilibria.

Unit – III Inorganic Reaction Mechanism: rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction (Direct chemical analysis, spectrophotometeric method, electrochemical and flow methods) Ligand substitution reactions of a) Octahedral complexes without breaking of metal ligand bond (use of isotopic labelling method), b) square planar complexes, trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions. Redox reaction: inner and outer sphere mechanisms, complimentary and non complimentary reactions. Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemisation reaction and applications)

Unit – IV Organometallic Chemistry of Transition metals: Eighteen and sixteen electron rule and electron counting with examples. Preparation and properties of the following compounds: alkyl and aryl derivatives of Pd and Pt compounds, carbenes an carbines of Cr, Mo and W, alkene derivatives of Pd and Pt, alkyne derivatives of Pd nad Pt, allyl derivatives of nickel, sandwich compounds of Fe, Cr and Half sandwich compounds of Cr, Mo. Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: Zeise's salt, bis(triphenylphosphine)diphenylacetylene platinum, diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl(n^2-butadiene)iron(0).

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity

and understanding of the basic concepts of subject area.

- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme classroom discussion will also be a part of learning activity.

Recommended Books:

1. Ligand field theory & its applications: B.N. Figgis & M.A. Hitachman (2000) Wiely VCH Publ.
2. Symmetry and spectroscopy of molecules, Second Edn, by K. Veera Reddy, New Age International Publication, 2009.
3. Elements of magnetochemistry, R. L. Datta and Syamal, Second Edn, Afiliated East West Press Pvt. Ltd. 2007.
4. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.
5. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000.
6. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.
7. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
8. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.

Practical
Course Outline: This includes the quantitative separation and determination of pairs of metal ions using gravimetric and volumetric methods. Lastly it explains the Separation of a mixture of cations/anions by paper chromatographic technique.

1. Quantitative separation and determination of the following pairs of metal ions using gravimetric and volumetric methods.
   i. Ag^{+} (gravimetrically) and $Cu^{2+(}$Volumetrically)
   ii. Cu^{2+} (gravimetrically) and Zn^{2+}(Volumetrically)
   iii. Fe^{3+} (gravimetrically) and Ca^{2+}(Volumetrically)
   iv. Mg^{2+} (gravimetrically) and Ca^{2+}(Volumetrically)
2. Separation of a mixture of cations/anions by paper chromatographic technique using aqueous/non-aqueous media.
   i. Pb^{2+} and Ag^{+} (aqueous and non-aqueous media), Co^{2+} and Cu^{2+} (non-aqueous medium)
   ii. Cl^{-} and I^{-} (aqueous-acetone medium) , Br^{-} and I^{-} (aqueous-acetone medium)

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM105	L	T	P	**Credits**
Course Name:	Summer Internship	0	0	2	2

Course Outline:
This course will allow student to understand requirements and gain confidence to develop work culture in an Industry. Student will develop knowledge of application of chemistry concepts and principles.

Unit I Project conduct at Industry / R&D / etc.

Unit II Report Preparation and Submission

Unit III Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, experimental work at Industry / R&D / etc. and presentations.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Semester – II

Course Code:	MSCM201	L	T	P	**Credits**
Course Name:	Analytical Chemistry – II	4	0	2	**6**

Theory

Course Outline:

This course deals with the basics of electroanalytical and chromatographic techniques like GC and HPLC. It focuses on key texts from electrogravimetry, polarography and coulomtetry such as its origin, theory, instrumentation and applications. In addition, it explores the fundamental as well as detailed study of mass spectroscopy. The emphasis has been given to the practical application of the theory and to handle various instruments.

Aim of the Course:

After completing this course student will be able to:

- *understand the basics of electroanalytical and chromatographic techniques.*
- *acquire competency to predict the patterns in thermal methods of analysis.*

Unit – I Chromatography: recapitulation of basic concepts in chromatography, classification of chromatographic methods, requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to their applications (LC and GC respectively, qualitative and quantitative analysis. Concept of plate and rate theories in chromatography: efficiency, resolution, selectivity and separation capability. Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions. Gas Chromatography: Instrumentation of GC with special reference to sample injection systems – split/splitless, column types, solid / liquid stationary phases, column switching techniques, temperature programming, thermionic and mass spectrometric detector, Applications.

Unit – II High performance liquid chromatography (HPLC): Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography.

Unit – III Mass spectrometry: recapitulation, instrumentation, ion source for molecular studies, electron impact, filed ionization, field absorption, chemical ionization and fast atom bombardment sources. Mass analyzer: Quadrupole, time of flight and ion trap. Applications.

Unit – IV Electro analytical methods- Potentiometry, ion selective electrodes and their applications (solid state, precipitate, liquid-liquid enzyme and gas sensing electrodes), ion selective field effect transistors, biocatalytic membrane electrodes and enzymes based biosensors. Polarography- Ilkovic equation, derivation starting with Cottrell equation, effect of complex formation on the polarographic waves. Electrogravimetry: Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications. Coulometry: Introduction, principle, instrumentation, coulometry at controlled potential and controlled current.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Based upon the lectures and practical exercises students will be given some topics for self

study.

- Interactive sessions such as theme based quiz will also be a part of learning activity.

Recommended Books:

1. Royal Society of Chemistry, 1997.
2. Modern Analytical Chemistry, D. Harvey , McGraw Hill, 2000
3. Principles of Instrumental Analysis : Douglas Skoog, Pearson
4. Introduction to Instrumental Analysis: Robert Brown
5. Instrumental Method of Analysis : H. H. Willard, L. L. Merritt & J.A. Dean
6. Instrumental Methods of Chemical Analysis, B.K. Sharma, Goel Pub's House)
7. Working with Ion selective Electrodes, O.K. Camman.

Practical
Course Outline: It deals with the determination of salt concentration, a few estimations, TLC and column chromatographic separations etc. It involves various techniques such as ion exchange method, flame photometry, fluorimetry, GC and coulometry.

1. Determination of salt concentration by ion exchange method.
2. Assay of folic acid.
3. Estimation of Na+ and K+ by flame photometry.
4. Estimation of quinine by fluorimetry.
5. TLC separation of sugars and amino acids.
6. Column chromatographic separation and estimation.
7. Determination of purity of ascorbic acid.
8. Quantitative determination by GC
9. Estimation of detergents by coulometry.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM202	L	T	P	**Credits**
Course Name:	Organic Chemistry –II	4	0	2	**6**

Theory

Course Outline:

This course explores the importance of pericyclic reactions and the concept of different reaction mechanism. The first part of the course includes Woodward-Hoffmann rules and a detailed study of a few important pericyclic reactions. The last part involves the reactions and the mechanisms involved therein including various important name reactions. Detailed study of various organomettalic reagents are also the part of the course

Aim of the Course:

After completing this course student will be able to:

- *explain the importance of pericyclic reactions.*
- *understand the concept of different reaction mechanism.*

Unit – I Organic reaction mechanisms- Organic reactive intermediates, methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes. Neighbouring group participation: Mechanism and effects of anchimeric assistance, NGP by unshared/ lone pair electrons, π-electrons, aromatic rings, σ-bonds with special reference to norbornyl and bicyclo[2.2.2]octyl cation systems (formation of non-classical carbocation) Role of FMOs in organic reactivity: Reactions involving hard and soft electrophiles and nucleophiles, ambident nucleophiles, ambident electrophiles, the α effect.

Unit – II Synthetic Organic Chemistry- Oxidation reactions: CrO_3, PDC, PCC, $KMnO_4$, MnO_2, Swern, SeO_2, $Pb(OAc)_4$, Pd-C, OsO_4, mCPBA, O_3, $NaIO_4$, HIO_4. Reduction reactions: Boranes and hydroboration reactions, R_3SiH, Bu_3SnH, MPV, H_2/Pd-C, Willkinsons, $NaCNBH_3$, NH_2NH_2, DIBAL. Rearrangements: Beckmann, Hofmann,, Curtius, Smith, Wolff, Lossen, Bayer-villiger, Sommelet, Favorskii, Pinacol-pinacolone, Benzil-benzilic acid, Calsien, Cope, Fries. Ylides: Phosphorus, Nitrogen and Sulphur ylides. Addition to carbon-heteroatom multiple bonds: Grignard, organo zinc, organo copper, organo lithium, reagents to carbonyl and unsaturated carbonyl compounds.

Unit – III Applications of UV and IR spectroscopy:Ultraviolet spectroscopy: Recapitulation, UV spectra of dienes, conjugated polyenes (cyclic and acyclic), carbonyl and unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents). Infrared spectroscopy: Fundamental, overtone and combination bands, vibrational coupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds.

Unit – IV NMR spectroscopy- Proton magnetic resonance spectroscopy: Principle, Chemical shift, Factors affecting chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to

carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal and long range coupling (allylic and aromatic). First order spectra, Karplus equation. 13C NMR spectroscopy: Theory and comparison with proton NMR, proton coupled and decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based quiz will also be a part of learning activity.

Recommended Books:

1. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
2. Modern Synthetic reactions- H.O. HouseOrganic Chemistry, Stanley H. Pine
3. Organic Synthesis – M.B. Smith
4. Advanced Organic Chemistry (part A & B)– A. Care y and R.J. Sundberg
5. Stereochemistry conformations and mechanism by P.S. Kalsi
6. Organic chemistry –by Cram, Hammond, Pine and Handrikson
7. Introduction to spectroscopy – D.l. Pavia, G.M. Lampman, G.S. Kriz, 3rd Edition
8. Spectroscopic methods in organic molecules – D.H. William & I Flemming Mc Graw Hill
9. Mechanism and Structure in Organic Chemistry - E.S. Gould

Practical
Course Outline: It involves the syntheses of organic compounds which include two steps only. In addition organic estimations of mixtures and Isolation of caffeine from natural sources are included in the course.

1. Preparation of compounds involving not more than two steps.
2. Organic estimations of mixtures – acid & amide, acid & ester, estimation of starch & estimation of total reducing sugar content.
3. Isolation of caffeine from tea leaves / to isolate casein and lactose from Milk.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM203	L	T	P	**Credits**
Course Name:	Physical Chemistry –II	4	0	2	**6**
Theory					

Course Outline:

This course is designed to explain a few important aspects of physical chemistry such as statistical thermodynamics and fugacity of gases. Properties of ideal solutions and the law governing it like Raoult's Law, Henry's Law, Duhem-Margules equation have will be studied in detail in this course. Free energy and chemical equilibrium shall also be studied in this unit.

Aim of the Course:

After completing this course student will be able to:

- *understand the concept of Statistical Thermodynamics*
- *insights into ideal solutions and their properties*
- *study of fugacity of gases*
- *understanding the concept of nuclear chemistry and radiochemistry.*

Unit – I Statistical Thermodynamics Introduction, Aspects of statistics, Definition of microscopic states, Statistical weight, Macroscopic states, Most probable distribution system, Assembly, Assembly of localized and non-localized systems, Ensemble, Micro-canonical ensemble, Macro canonical ensemble and grand canonical ensemble, Boltzmann and Planck equation, Maxwell Boltzmann, Fermi-Dirac and Bose-Einstein Statistics, Partition function and its significance, Translational, Rotational, Vibrational and Electronic partition functions and their evaluation, Thermodynamic properties in terms of partition functions, Internal energy, Molar heat capacity, Entropy and free energy functions, Translational, rotation and vibrational entropies of ideal mono atomic gases, SackurTetrode equation, Statistical expression for equilibrium constant for metathetic reactions, Numericals

Unit – II The Properties of Solutions, Ideal solutions & its properties, The Duhem-Margules equation, Application of Raoult's law to both constituents of an ideal solution, Vapour Pressure curves for an Ideal solution, Composition of liquid & vapour in equilibrium, Non-ideal solutions & its vapour pressure curves, Dilute solutions, Henry's Law. Solutions of electrolytes: Mean ionic activity, Mean ionic activity coefficient & mean ionic molality of the electrolyte, Listing of the methods determining mean ionic activities, Ionic strength principle, Numericals.

Unit – III Fugacity and Activity Introduction, Definition of fugacity, Methods of determining Fugacity of a gas: Graphical method, Equation of State method, Approximate and Generalized methods, Variation of Fugacity with temperature and pressure, Fugacity of solids and liquids, Mixture of Ideal and Real gases, Determination of Fugacity in gas mixtures, The Lewis-Randall rule, Variation of fugacity of a gas in a mixture with temperature and pressure, Numericals. Partial Molar Properties Introduction, Fundamental equations, Thermodynamic significance, Apparent molar property, Relation between Apparent molar property & Partial molar property in the case of an infinitely dilute solution, Methods of determining Partial molar properties: Direct method, Intercept method & Use of apparent molar property method, Partial molar volumes from density measurements, Determination of apparent molar volume of solute, Numericals.

Unit – IV Free Energy and Chemical Reactions, Chemical Equilibrium, The equilibrium constant, Equilibrium in homogeneous gaseous systems, The ammonia equilibrium, Homogeneous reactions in liquid solutions as well as in dilute solutions, The reaction isotherm, Standard free energy of reaction, The direction of chemical change, Variation of equilibrium constant with

pressure and temperature, Integration of the Van't Hoff equation, Variation of standard free energy with temperature, Determination of standard free energies, Numericals.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based quiz will also be a part of learning activity.

Recommended Books:

1. Atkins' Physical Chemistry, P. W. Atkins and De Paula, 8th edition (2010).
2. Physical Chemistry, T. Engel and P. Reid, Pearson Education (2006).
3. Physical Chemistry a Molecular approach, D. Mcquarie and J. Simon (University Science) 2000.
4. Physical Chemistry for Biological Sciences by Raymond Chang (Universal Books), 2000.
5. Terry L. Hill, (1987) Introduction of Statistical Thermodynamics, First Edition, Dover Publications, New York.
6. M. C. Gupta, (1990)Statistical Thermodynamics, Second edition, New Age International Publications, New Delhi
7. 6. T. Engel and P. Reid, (2007)Thermodynamics: Statistical Thermodynamics and Kinetics, First Edition, Pearson Education, Noida

Practical
Course Outline: It explores the basic techniques used in physical chemistry. It deals with the construction of phase diagram, potentiometric titration, determination of molecular weight, CMC, solubility product, half life, Degree of hydrolysis, Dissociation constants etc. This involves various techniques such as viscometry, surface tension method, potentiometrically, kinetics method and potentiometer.

1. Phase diagram of a binary organic system.
2. Potentiometric titration of a strong acid with strong base using quinhydrone electrode.
3. Potentiometric titration of a redox system (ferrous ammonium sulfate with $K_2Cr_2O_7$).
4. Moleular weight of polymer by viscometry.
5. CMC by surface tension method
6. Determination of solubility and solubility product of sparingly soluble salt potentiometrically
7. Decomposition of diacetone alcohol by dilatometry.
8. Degree of hydrolysis of urea hydrochloride by kinetics method.
9. Dissociation constants by dilution method using potentiometer.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM204	L	T	P	**Credits**
Course Name:	Inorganic Chemistry – II	4	0	2	**6**

Theory

Course Outline:

It explains the importance of quantum chemistry and its role in developing the model of the atom. It also discusses the origin of Schrodinger wave equation and its application in calculating the energy and wave functions of various atomic and molecular systems. Metal – Ligand Bonding in Transition Metal Complexes is also elaborately explained. In addition, it describes the concepts of metal complexes and its behaviour.

Aim of the Course:

After completing this course student will be able to:

- *explain the importance of quantum chemistry in developing the model of the atom.*
- *understand the origin of Schrodinger wave equation and its application in calculating the energy and wave functions of various atomic and molecular systems.*
- *understand the concepts of metal complexes and its behaviour.*

Unit – I Definitions and Theorems of Group Theory, Molecular Symmetry and Symmetry Groups, Symmetry elements and operations, symmetry planes and reflections, the inversion centre, proper axes and proper rotations, improper axes and improper rotations, products of symmetry operations, equivalent symmetry elements and equivalent atoms, general relations symmetry elements and symmetry operations, symmetry elements and optical isomerism, symmetry point groups, classes of symmetry operations, classification of molecular point groups.

Unit – II Representation of Groups: Matrix representation and matrix notation for geometric transformation, The Great Orthogonality Theorem and its consequence, character tables (No mathematical part) Group theory and quantum mechanics: Wave function as basis for irreducible representations. Symmetry adapted linear combinations: Projection operators and their use of construct SALC (Construction of SALC for sigma bonding for molecules belonging point groups: D_{2h}, D_{3h}, D_{4h}, $C4_v$, Td, Oh, normalization of SALC.

Unit – III Hydrogen and its compounds: Hydrides: Classification, electron deficient, electron precise and electron rich hydrides. PH_3 SbH_3, AsH_3. Selenides, Tellurides. Alkali and alkaline earth metals: solutions in non-aqueous Media, Applications of crown ethers in extraction of alkali and alkaline earth metals. Organometallic Compounds of Li, Mg, Be, Ca, Na: Classification, synthesis properties uses and structures.

Unit – IV Boron group, Carbon group, Organometallic Compounds of Si, Sn, Pb, Ga, As, Sb, Bi, Structure, synthesis, reactions, Nitrogen group, Oxygen group, Halogen group.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based quiz will also be a part of learning activity.

Recommended Books:

1. Chemical Applications of Group Theory, Third Edn., Author - F. A. Cotton (Wiley, New York)

2. Symmetry and spectroscopy of molecules, Second Ed. 2009: Author- K. Veera Reddy, (New Age International Publication)
3. Group Theory and its Chemical Applications, P.K. Bhattarchrya
4. Inorganic Chemistry : Shriver & Atkins (4th edition 2003, Oxford)
5. Concise Inorganic Chemistry, J. D. Lee, Fourth Edn.(Chapman and Hall)
6. Inorganic chemistry: principle of structures and reactivity, Huheey, Keiter, Keiter, Medhi, Pearson Education, Fourth Edn.(2007).
7. Inorganic Chemistry: Catherine Housecroft
8. Inorganic Chemistry: Messler & Tarr, Pearson Publishers 3rd Edition
9. Organometallic Chemistry-A Unified Approach: R. C. Mehrotra & A. Singh

Practical
Course Outline: It deals with the syntheses, purification and structural studies (magnetic, electronic and IR) of inorganic complex compounds. In addition, analysis of Alloys are also included as part of the course.
1. Preparation, purification and structural studies (magnetic, electronic and IR) of inorganic complex compounds. 2. Analysis of Alloys – Bronze, nickel based alloy, solder metal, white metal, duralumin

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM205	L	T	P	**Credits**
Course Name:	Summer Internship	0	0	2	2

Course Outline:
This course will allow student to understand requirements and gain confidence to develop work culture in an Industry. Student will develop knowledge of application of chemistry concepts and principles.

Unit I Project conduct at Industry / R&D / etc.

Unit II Report Preparation and Submission

Unit III Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, experimental work at Industry / R&D / etc. and presentations.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Final Year (Analytical Chemistry)

Course Code:	MSCM301	L	T	P	**Credits**
Course Name:	Analytical Chemistry – III	4	0	2	**6**
Theory					

Course Outline:

This course is designed to provide a fundamental overview of analytical techniques to students interested in pursuing a career in the Chemistry. This course will include the study of development of analytical methods and types of error involved in measurements. It will also cover the types of sampling techniques and sample preparation. The study of GLP and GMP shall also done included in this course.

Aim of the Course:

After completing this course student will be able to:

- *studying concepts of sampling*
- *Measurement of uncertainty*
- *study of development of analytical methods and types of error*

Unit – I Sampling: Definition, types of sample, sampling plan, quality of sample, subsampling, sampling of raw materials, intermediates and finished products. Sample preparations-dissolution technology and decomposition, storage of samples. Pre-treatment of samples: soil, food and cosmetics. Selection of the method: sources of methods, factors to consider when selecting a method, performance criteria for methods used, reasons for incorrect analytical results, method validation, and quality by design (PAT).

Unit – II Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results. Signal to noise: Signal to noise ratio enhancement, hardware devices for noise reduction, software methods for noise reduction. Pharmaceutical legislation: introduction to drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration.

Unit – III Analytical method developments and validation: Assay validation and inter laboratory transfer: Introduction, fundamental definitions, essential principles of method transfer, method validation report, the inter-laboratory qualification (ILQ) process. Statistical analysis and analytical figure of merit: Introduction, errors (gross errors, systematic errors, random errors), accuracy, validation parameters: Accuracy, precision, mean and standard deviation, calibration, {linear response functions (linear regression-errors in slope and the intercept, error in the estimate of concentration, standard additions), non-linear response functions and weighted regression analysis, internal standards}, single point vs multiple point calibration, selectivity and specificity (chromatographic methods), limits of detections (spectrophotometric methods, chromatographic methods and related techniques, receptor binding assay), limit of quantification, sensitivity, ruggedness and robustness, analyte stability in the sample matrix, how to reduce systematic errors, comparison of results, comparison of two means of two samples, experimental design.

Unit – IV Specific methods and applications: Dissolution studies, Introduction, dissolution test, apparatus – USP type – I and II, sampling and analytical instrumentation, Dissolution.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.

- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study. Interactive sessions such as theme based on class room assignment will also be a part of learning activity.

Recommended Books:

1. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Harcourt Brace & Company, Florida.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
3. J.M. Hollas, Modern Spectroscopy, 3rd Edition (1996), John Wiley, New York.
4. H.A. Strobel, Chemical Instrumentation - A Systematic Approach, 2nd Edition (1973), Addison Wesley, Mass.

Practical
Course Outline: Analytical Chemistry Laboratory course has been designed on the basis of different techniques introduced in theory courses. both the laboratory courses lay emphasis on practically employing the different methods useful for analytical chemistry person & will give hands on experience of spectrophotometer, colorimeter, voltameter, polarograpy method, pH meter, chromatography, Karl Fischer instrument etc.

1. Determination of Al/Mg 8-Hydroxyquinoline as complexing agents by spectrophotometric method
2. Determination of sulphate by Turbidimetry
3. Analysis of vitamin A in food products.
4. Analysis of vitamin C in juices and squashes.
5. Determination of soap value and iodine value of oil.
6. Estimation of the purity of a given azo dye by colorimetry.
7. Determination of moisture in pharmaceuticals.
8. Estimation of nitrite in meat colorimetrically.
9. Estimation of mercury in skin ointment.
10. Chemical analysis of chill/turmeric powder.
11. Estimation of Na, K and Li individually by Flame Photometry.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM302	L	T	P	**Credits**
Course Name:	Analytical Chemistry – IV	4	0	2	**6**

Theory

Course Outline:

In further addition to Spectrochemical analysis –I course, this course is designed to give more insights on the principles, instrumentation & applications of Ion exchange chromatography and Supercritical fluid chromatography.Emphasis is more on different analytical methods with their principles and applications.

Aim of the Course:

After completing this course student will be able to:

- *understand the principles of chromatographic techniques and various methods for the analysis.*
- *explain the importance separation techniques.*
- *gain sound knowledge in chromatographic techniques in the separation and identification of components.*

Unit – I Ion exchange chromatography: Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchanges, chelating resins and their applications for separation of inorganic and organic compounds. Ion chromatography; principle, instrumentation with special reference to separation and suppressor columns, applications. Exclusion chromatography: Theory, instrumentation and applications of gel permeation chromatography, retention behaviour, inorganic molecular sieves, determination of molecular weight of polymers.

Unit – II Supercritical fluid chromatography: Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis. Affinity chromatography: principle, instrumentation and applications, Optimum pressure liquid chromatography (OPLC).

Unit – III Thermal methods of analysis: Principle, different methods of thermal analysis, Thermal gravimetric methods of analysis: instrumentation, thermogram and information from thermogram, factors affecting thermogram, applications TGA for quantitative analysis (TG analysis of CaC_2O_4 H_2O, $CuSO_45H_2O$, dolomite ore, etc) and problems based TGA. Differential thermal analysis (DTA); Instrumentation, general principles, differential thermogram, DT and TG curve together, Applications (DT analysis of CaC_2O_4, H_2O DT analysis of sulphur, DT analysis of $CuSO_45H_20$). TG and DT curve for $Mn(PH_2O_2)2$ H_2O. Differential Scanning Calorimetry (DSC): Principle, instrumentation, and applications (DSC curve of polyethylene terphthalate, DSC curve for isothermal crystallization of polyethylene, DSC of phenacetein), thermometric titrations, evolved gas analysis.

Unit - IV Radioanalytical Methods of Analysis: Activation analysis, Neutron activation analysis, principle, technique, steps involved in neutron activation analysis. Radiochemical and instrumental methods of analysis, important applications of NAA. Isotope dilution analysis: Principle, types of isotope dilution analysis, typical applications of isotope dilution analysis. Radiometric titration: Principle, techniques based on complex formation and precipitation, radiometric titration curves for estimation of ions from their mixture.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self

study.

- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. H. Kaur, Instrumental Methods of Chemical Analysis, Pragati Prakashan , Meerut.
2. W H Willard, L L Merritt and J A Dean, Instrumental Methods of Analysis.
3. S. M.Khopkar, Basic Concepts in Analytical Chemistry.
4. E. Berlin, Principles and Practice of X-Ray Spectrometric Analysis, Plenum, NewYork.
5. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Harcourt Brace & Company, Florida.
6. Thermal analysis by W.W. Wendlandt, John Wiley, (1986)

Practical
Course Outline: Analytical Chemistry Laboratory course have been designed on the basis of different techniques introduced in theory courses. both the laboratory courses lay emphasis on practically employing the different methods useful for analytical chemistry person & will give hands on experience of spectrophotometer, colorimeter, voltameter, polarograpy method, pH meter, chromatography, Karl Fischer instrument etc.

1. Kjeldahl's method of protein estimation in foods and feeds.
2. Determination of strength of acetic acid I commercial vinegar by conductometric method.
3. Simultaneous estimation of Cl and I by potentiometric method
4. Determination of concentration of Fe ion in ferric salicylate complex Spectrophotometrically Estimation of calcium from chalk.
5. Colorimetric and spectrophotometric determination of manganese in steel
6. Determination of total salts by cation exchange.
7. Anion exchange separation of Iron, cobalt and nickel.
8. Calculation of standard deviation from the results obtained by redox titration of Fe(III) against standard solution of $K_2Cr_2O_7$
9. Estimation of Ibuproven/Paracetamol in a pharmaceutical sample.
10. Analysis of milk
11. Determination of ferrous ammonium sulfate potentiometrically with standard ceric sulfate solution (Direct and back titration).

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM303	L	T	P	**Credits**
Course Name:	Analytical Chemistry – V	4	0	2	**6**

Theory

Course Outline:

This course has been formulated to give an overview of different separation techniques being used in chemistry. The course primarily deals with electroanalytical and atomic spectroscopic techniques – introduction, principle of separation, different & its industrial applications. The course also includes information about Classical approach for aqueous extraction.

Aim of the Course:

After completing this course student will be able to:

- *explain the importance separation techniques.*
- *understand the concept of spectroscopic analysis.*

Unit – I Advanced Electroanalytical Techniques: Current sampled (TAST) polarography, normal and differential pulse polarography. Potential sweep methods, linear sweep voltammetry and cyclic voltammetry. Potential step method- Chronoamperometry, controlled potential technique-Chronopotentiometry, stipping voltammetry – anodic, cathodic and adsorption. Chemically and electrolytically modified electrodes and ultra-microelectodes in voltammetry.

Unit – II Atomic spectroscopy: Theory, sources, burners, atomic emission spectra, atomic absorption spectra, effect of temperature on emission, absorption and fluorescence, electro thermal atomizers, Instrumentation for FES, radiation sources atomic absorption methods, instrumentation of AAS, spectral interference, standard addition and internal standard method of analysis, comparison of atomic absorption and emission methods, inductively coupled plasma and direct current plasma emission spectroscopy, cold vapour technique, applications of AAS, AES and ICPAES, analysis of micronutrients like Mo, B, Cu, Zn essential towards the healthy growth of crops, fruits, determination of these micronutrients from soils, plants and fruits.

Unit – III Atomic mass spectroscopy-II: Features of atomic mass spectroscopy, atomic weight in mass spectroscopy, mass to charge ratio, types of atomic mass spectroscopy, mass spectrometers, transducer for mass spectroscopy, quadrapole mass analyzer, time of flight mass analyzer, inductively coupled mass spectroscopy (ICPMS), instrumentation for ICPMS, atomic mass spectra and interferences, applications of ICPMS. Atomic Fluorescence Spectroscopy (AFS): Atomic fluorescence, apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasma, Wavelength selection for AFS, Detectors for AFS, theory of AFS, analysis with AFS, interference with AFS. Resonant Ionization Spectroscopy, Laser-enhanced ionization spectroscopy.

Unit – IV Classical approach for aqueous extraction: Introduction, liquid – liquid extraction (LLE) (Theory of LLE, selection of solvents, solvent extraction, problems with LLE process), purge and trap for volatile organics in aqueous samples. Solid Phase Extraction (SPE): Introduction, types of SPE media, SPE formats and apparatus, method for SPE operation, solvent selection, factors affecting SPE, selected methods of analysis for SPE, automation and on line SPE. Solid Phase Micro-Extraction: Introduction, theoretical consideration, experimental, methods of analysis: SPME-GC, methods of analysis: SPME-HPLC-MS, automation of SPME, new development in micro extraction (liquid micro extraction, membrane micro extraction).

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.

- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Instrumental methods of chemical analysis by Chatwal and Anand.
2. Fundamentals of Analytical Chemistry, 6th edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing.
3. Introduction to instrumental analysis by R.D.Broun, Mc Graw Hill (1987)
4. Instrumental methods of chemical analysis by H. willard, L.Merrit, J.A. Dean and F.A. settle Sixth edition CBS (1986)
5. Cyclic Voltammetry and frontiers of electrochemistry by N.Noel and K.I. Vasu IBH, New Delhi (1990)

Practical
Course Outline: Analytical Chemistry Laboratory course have been designed on the basis of different techniques introduced in theory courses. both the laboratory courses lay emphasis on practically employing the different methods useful for analytical chemistry person & will give hands on experience of spectrophotometer, colorimeter, voltameter, polarograpy method, pH meter, chromatography, Karl Fischer instrument etc.

1. To obtain the protolysis curves involving cases of weak acid, mixture of acids and polybasic acid employing a *pH* meter and determine the amount of the respective acid (in ppm) in the given solution.
2. Determination of Na_2CO_3 content (in %) of washing soda using a pH meter.
3. Determination of trace metal impurities present in a polluted water sample by anodic stripping voltammetric procedure.
4. Separation of proteins by polyacrylamide gel electrophoresis.
5. Determination of the capacity of an ion exchange (cationic and anionic) resin (column method).
6. Separation of nickel, manganese, cobalt and zinc and determination of Rf values by thin layer or paper strip techniques.
7. To identify the mixture of inorganic cations. (Co^{2+}, Fe^{2+} and Ni^{2+}) by circular paper chromatography.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM304	L	T	P	**Credits**
Course Name:	Computer Application in Chemistry	4	0	0	**4**
Theory					

Course Outline:

This Course provides the knowledge of utilization of computers in field of chemistry.Chemistry and chemical engineering, like many other disciplines, are being profoundly influenced by increased computing power.The small applications developed in programming aims to produce results for given values of constants and for observed values of inputs for various experiments from curriculum.

Aim of the Course:

After completing this course student will be able to:

- *explain the importance of computers application in chemistry.*
- *acquire competency to use chemistry related software.*

Unit – I Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

Unit – II *Roots of equations:* Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.

Unit – III *Differential calculus:* Numerical differentiation. *Integral calculus:* Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values. *Simultaneous equations:* Matrix manipulation: addition, multiplication. Gauss-Siedal method.

Unit – IV *Interpolation, extrapolation and curve fitting:* Handling of experimental data. *Conceptual background of molecular modelling:* Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
2. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
3. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985).
4. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).
5. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
6. Steiner, E. The Chemical Maths Book Oxford University Press (1996).

Course Code:	MSCM305	L	T	P	**Credits**
Course Name:	**Research Methodology and Scientific Communication Skills**	4	0	0	**4**

Course Outline:

This course is an applicative course and gives an insight to the working in research. Through this course students shall gain exposure to the different techniques and methods used in historical science .It enhances communication skill process in science web.

Aim of the Course:

After completing this course student will be able to:

- *To generate Curiosity about some ideological research work.*
- *Gain effective and interactive technical communication skill in science field.*

Unit – I History of science and science methodologies: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology. Choosing a mentor, lab and research question; maintaining a lab notebook. Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Unit – II Process of communication

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit – III Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non- blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct

Unit - IV Chemical Safety and Ethical Handling of Chemicals:

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based class room assignment will also be a part of learning activity.

Recommended Books:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011)
2. Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
3. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
4. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
5. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
7. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
8. OSU safety manual 1.01.

Semester IV (Analytical Chemistry)

Course Code:	MSCM401	L	T	P	**Credits**
Course Name:	Analytical Chemistry – VI	4	0	0	4
Theory					

Course Outline:

The course is designed to give insights about pharmaceutical industries reflecting By role of FDA. The course will also help students to understand & appreciate the methods involved in analysis of vegetable drugs and shelf life of pharmaceutical product.

Aim of the Course:

After completing this course student will be able to:

- *understand the role of FDA in pharmaceutical industries..*
- *To analyse* the vegetable drugs and some raw materials with respect to identification.

Unit – I Apparatus for test and assay, cleaning of glassware's. Role of FDA in Pharmaceutical Industries: Definitions of drug and cosmetics, substandard drugs, role of FDA, introduction to new drug, development of new drugs selection of area, phase I, phase II, phase III, application of FDA for formulation and marketing for new drug, stability studies and self life fixation.

Unit – II Biological Tests and Assay: Introduction to biological assay, biological assay of Heparin sodium, determination of amylase activity, determination of photolytic activity, test for insulin in solution, biological assay of tetanus antitoxin, test for undue toxicity. Microbiological Tests and Assays: Microbiological test for antibiotic standard preparation and units of activity, test organisms and inoculums, cylinder-plat assay receptacles, turbidimetric assay receptacles, assay designs, cylinder plate or cup plate method, two level fractional assay, test for sterility. Physical test, determinations, limit tests and sterilization: Disintegration test for tablets and capsules, dissolution test for tablets and capsules, moisture/water content by Karl Fischer titration, limit test for arsenic, heavy metals, iron, lead, sulphate, chloride, ash, sulphated ash, methods for sterilization steam sterilization, dry heat sterilization, sterilization by filtration, gas sterilization, sterilization by ionizing radiation, sterilization by heating with bactericides, water for pharmaceutical use.

Unit – III Analysis of vegetable drugs: Vegetable drugs, sampling, foreign organic matter, ash value, acid soluble ash, acid insoluble ash, sulphated ash, extraction of alkaloids. Source of impurities in pharmaceutical raw materials and finished products, shelf life of pharmaceutical product. Raw materials, method of manufacture, atmospheric contaminations, cross contamination, microbial contamination, container contamination, packaging errors, chemical instability, temperature effect and physical changes, shelf life of pharmaceutical product and determination of shelf life.

Unit – IV Analysis of raw materials with respect to identification, other or related substances, loss on drying, and assay as per IP, adrenaline, niacinamide, cephalexin, ferrous fumarate, isoniazid and paracetamol. Problems based on assay of these materials. Brief introduction to different dosage forms with the IP requirements analytical methods for the following tablets, different types of tablets uniformity in weight (aspirin) additives used in tablet manufacture, capsules, types of capsules, (Rifampicin) powders (Sodium benzoate), solutions (Saline NaCl) suspensions (Barium Sulphate – limit test for impurity) Mouthwashes (Ointments (salicylic acid) and creams Dimethicone by IR) Injections (Mannitol), ophthalmic preparations (sulphacteamine), aerosols (salbutamol), Blood products and reporting protocols, Problems based on assay of these materials.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely. Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Practical Pharmaceutical chemistry third edition volume 1 by A.H.Beckett & J.B.Stenlake
2. Pharmacoepia of India Volume I and II.
3. Remington‘s Pharmaceutical sciences.
4. Forensic pharmacy by B.S Kuchekar, A.M Khadatare (Nirali Prakashan)
5. Practical pharmaceutical analysis by Ashitosh Kaur
6. Analytical problems of drug substances and Exp by Florey
7. The theory and practice of Ind pharmacy Leon lachmann,Herbert Liebermann and Joseph L.Karnic 3rd edition By Varghese Publication House, Hind Rajasthan Building Dadar Mumbai - 14

Course Code:	MSCM402	L	T	P	**Credits**
Course Name:	Analytical Chemistry – VII	4	0	0	**4**
Theory					

Course Outline:

In further addition to Spectrochemical analysis –I course, this course is designed to give more insights on the principles, instrumentation & applications of Fluorescence, Phosphoresence, Electron spectroscopy and X-ray spectroscopy. Emphasis is more on the structural elucidation of different molecules using these spectroscopic techniques.

Aim of the Course:

After completing this course student will be able to:

- *understand the principles of Fluorescence, Phosphorescence,Electron spectroscopy, X – ray spectrosocpy,* chemiluminescences.
- *interpret given spectra to elucidate the structures of molecules.*

Unit – I Electron spectroscopy: Introduction, principle of ESCA, electron spectroscopy for chemical analysis, ESCA satellite peaks, spectral splitting, ESCA chemical shifts, apparatus used for ESCA, X-ray source, samples, Analyzers, Detectors, chemical analysis using ESCA, Applications, Auger electron microscopy, ultraviolet photoelectron spectroscopy.

Unit – II X-ray methods of analysis: Principle, theory X-ray spectral lines, X-ray tube, X-ray emission, absorptive apparatus, sources, collimation, sample handling, wavelength dispersive devices, energy dispersive devices, detectors, readout device, chemical analysis using X-ray absorption, X-ray fluorescence – instrumentation and chemical analysis, X-ray diffraction, chemical analysis with X-ray diffraction, numerical problems.

Unit – III An introduction to microscopy: Limitation of the human eye, the X-ray microscope, the transmission electron microscope, the scanning electron microscope, scanning transmission electron microscope, analytical electron microscopy, scanning probe microscopes, the transmission electron microscope.

Unit - IV Chemiluminescences: Introduction, principle, types, measurement of chemiluminescence, instrumentation quantitative chemiluminescences, gas phase chemiluminescence's analysis, Chemiluminescences titrations, electro-chemiluminescence. Fluorescence and phosphorescence: Introduction, Fluorescence, photo luminescent theory, electron transitions during photoluminescence, factors affecting photoluminescence, luminescent apparatus, optical extractive sources, wavelength selectors, detectors and readout devices, photo luminescent spectra, photo luminescent analysis, analysis of non-photoluminating compounds, determinations of mixtures, specific examples of analysis using photoluminescence, problems.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
2. Analytical spectroscopy by Kamalesh Bansal- First edition.
3. Instrumental methods of chemical analysis by Willard, Dean and Merittee- Sixth edition.

4. Analytical chemistry principles by John H. Kenedey- Second edition, Saunders college publishing.
5. Electron microscopy in the study of material, P. J Grundy and G. A Jones, Edward Arnold.
6. Standard methods of chemical analysis- F. J. Welcher, part-B sixth edition (1966) D. van Nosrtand Company. Inc. 19

Course Code:	MSCM403	L	T	P	**Credits**
Course Name:	Analytical Chemistry – VIII	4	0	0	**4**

Course Outline:

The course will help students to gain knowledge of different methods for the analysis of fertilizers. Influenced the information about the some important methods regarding analysis of soaps, detergents and water pollutants and pigments.

Aim of the Course:

After completing this course student will be able to:

- *gain knowledge on analysis of fertilizers, paints, soaps, detergents.*
- *develop knowledge in* Water pollution and analysis of polluted water.

Unit – I Analysis of Fertilizers: Sampling and sample preparation, water, total nitrogen: Kjeldahl method, total nitrogen by reduced iron method, urea nitrogen, total Kjeldahll nitrogen methods and spectrophotometric method, Ammonia nitrogen. Phosphorus: total phosphorus, available and non-available, alkali metric ammonium molybdophosphate method, water soluble phosphorous, citrate insoluble phosphate, Potassium: potassium by sodium tetra phenyl borate method, flame photometric methods.

Unit – II Analysis of soaps and detergents: General scheme of analysis, sampling, alcohol soluble material, moisture and volatile matter, active ingredient and equivalent combined SO_3^{3-}, Tests for soaps: total fatty acids, fatty anhydride combined alkali, and anhydrous soap, Unsponified and unsaponifiable matter, free alkali or free acid, titer test, Iodine value, saponification value, free glycerol, tests for synthetic detergents: Unsulfonated or unsulfated matter ester SO_3, Combined alchohols, total combined SO_3, alkalinity, chorides, silicate, phosphate, borates, UV Spectroscopic analysis of detergents: Biodegradability of detergents, determination of sodium alkyl benzene sulfonate, determination of sodium toluene sulfonate, determination of sodium xylene sulfonate, determination of germicides in soaps and detergents.

Unit – III Water pollution and analysis of polluted water: Water pollutants, waste water treatment: domestic waste water treatment, aerobic treatment process, anaerobic treatment process, industial waste water treatment. The purpose of chemical analysis, sampling of water, pH of water, specific conductance, determination of acidity and alkalinity, chemical oxygen demand, biological oxygen demand, dissolved oxygen, turbidity, determination of aluminium, arsenic, boron, cadmium, calcium, carbon dioxide, chloride, residual chlorine, chorine demand, chromium, chromium, cyanide, total hardness, iron, lead manganese, Zn, methane, nitrate, nitrite, ammonia nitrogen, phenols, phosphates, silica, sulphate, sulphide anionic detergents, tannin and lignin.

Unit – IV Analysis of paints and pigments: Introduction, test on the total coating, water content, separation of pigment binder and thinner of solvent type coating, separation of pigment binder and thinner of latex paints, Identification of the binder, indentification of polymer resins and oils, identification of plasticiser, analysis of the vehicle, identification and analysis of pigments, indentification of inorganic pigments, analysis of white and tinted pigment, outline of general procedure, HCL insoluble, titanium dioxide, total lead, acid soluble Al and Fe, acid soluble calcium, total zinc, antimony oxide, total sulphate, total carbonate) analysis of colored pigments, black pigments, other pigments, identification and analysis of thinners.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.

- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Standard methods of chemical analysis, volume 3, part-B, F.J. Welcher.
2. Cosmetics by W.D. Poucher (Three volumes)
3. Insight into speciality inorganic chemicals by D. Thomson, the royal society of chemistry (1995)
4. Industrial water pollution control by W.W. Ecken and elder, Tata McGraw-Hill (2000)
5. Applied chemistry, a text book for Engineers and technologists by H.D. Gesser.
6. Handbook of Industrial chemistry, by Davis Berner.
7. Air pollution by Rao and Rao
8. Standard methods of water and waste water analysis by A.K. De.
9. Standard Methods of Chemical Analysis, Sixth Edition, Volume two-Part B Frank J. Welcher
10. Quantitative analysis by vogels.

Course Code:	MSCM404	L	T	P	**Credits**
Course Name:	Analysis and Characterization of Polymers	4	0	0	**4**

Course Outline:

This course is an applicative course and gives an insight to the working in a Polymer industry. Through this course students shall gain exposure to the different techniques and methods used in polymer chemistry as well as its several levels of applications in our daily life.

Aim of the Course:

After completing this course student will be able to:

- *explain the general properties and importance of polymers which are widely used.*
- *understand the industrial application of polymers.*

Unit – I Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems. Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Unit – II

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships. (M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Free volume theory, WLF equation, Factors affecting glass transition temperature (T_g).

Unit – III Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

Unit - IV Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study. Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.

4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford
8. University Press.
9. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan(2010).
10. Kemp, W. Organic Spectroscopy, Palgrave

Course Code:	MSCM405	L	T	P	**Credits**
Course Name:	Analytical Chemistry -IX	4	0	0	**4**

Course Outline:

This course is an Introduction to, acute poisoning, toxicology. It also includes analysis of carbohydrates from food sample by different methods and information about determination of food preservatives.

Aim of the Course:

After completing this course student will be able to:

- *understand the diagnosis of acute poisoning and toxic effects on various substances.*
- *Gain the knowledge of different methods for the analysis of carbohydrates.*

Unit – I Diagnosis of acute poisoning, treatment of acute poisoning, the role of the clinical toxicology laboratory. Diagnosis of acute poisoning, treatment of acute poisoning, the role of the clinical toxicology laboratory.

Unit – II Toxicology: Isolation, identification and determination of: Narcotics-heroin and cocaine, stimulants-caffeine, amphetamines, depressants – barbiturates, benzodiazepines. Narcotics and psychotropic substances act: Definition- addict, cannabis (hemp), coca derivative, coca leaf, manufacture medicinal cannabis, narcotic drug, opium, opium derivative, opium poppy, poppy straw psychotropic substance, Illicit traffic, prohibition control regulation offence and penalties.

Unit – III Carbohydrates: Definition, classification and functions, analysis of carbohydrates from food sample by different method i) volumetric determination by Fehling's solution, ii) colorimetric analysis of carbohydrates by Folin Wu method, Nelson Somyogi method, iii) total carbohydrates by Anthrone method, iv) Estimation of starch by anthrone method, v) Determination method, vii) Estimation of crude fibbers. Proteins: Definitions and functions, analysis of proteins by Kjedahl's method, analysis of protein by Lowry method, Estimation of amino acids, by colorimetric method, Estimation of food grain for methionine content, protein digestibility in vitro, protein efficiency and net protein ratio, determination of net protein utilization, digestibility and biological value, Polyacrylamide gel electrophoresis of proteins. Analysis of Lipids: Estimation of oil in oilseeds, estimation of free fatty acids, saponification value of oils, iodine value, determination of acid value of oil, determination of peroxide value of oil, identification and quantification of fatty acid.

Unit – IV Determination of food preservatives: Definition, SO_2 legistration and determination byTanners method, nitrate and nitrites legistration and determination, boric acid legistration and determination, Benzoic acid legistration and determination, 4-hydroxybenzoate legistration and determination, ascorbic acid legistration and determination. Sweeteners: Saccharine identification and determination, colours: Identification by general methods, natural colours. Milk: Analysis of milk and milk products: composition of milk, analysis of milk with respect to pH, acidity, fates, casein content, lactose content, mineral content, adulteration of milk.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual understanding of the basic concepts of phytochemistry.
- Lectures from subject specialists will be conducted to enlighten the students on topics of phytochemistry.
- Based upon the lectures and practical exercises students will be given assignment work.

Recommended Books:

1. NityaAnand, J.S. Bindra and S. Ranganathan, Art in Organic Synthesis, 2nd Edition (1970), Holden Day, San Francisco.

2. S.W. Pelletier, Chemistry of the Alkaloids, (1970) Van Nostrand Reinhold Co., New York.
3. K.W. Bentley, The Alkaloids, Vol. I., (1957) Interscience Publishers, New York.
4. I. L. Finar, Organic Chemistry, Vol. II, 5th Edition (1975) Longman Ltd, New Delhi.
5. J.W. Apsimon, Total Synthesis of Natural Products, Vol. 1-6, Wiley-Interscience Publications, New York.
6. J.S. Bindra and R. Bindra, Creativity in Organic Synthesis.
7. J.S. Bindra and R. Bindra, Prostaglandins Synthesis.
8. S. Warren, Organic Synthesis: Disconnection Approach, (1982) Wiley, New York.
9. K. C. Nicolaou, Classics in Total Synthesis of Natural Products, Vol. I & II. J. Clayden, N. Greeves, S.

Course Code:	MSCM406	L	T	P	**Credits**
Course Name:	Environmental Analytical Chemistry	4	0	0	**4**

Course Outline:

This course is an Introduction to Environmental chemistry and study of environmental pollutants.

Aim of the Course

After completing this course student will be able to:

- *understand various aspects of air, water and soil chemistry.*
- *relate chemical constituents present in the environment, interactions between them and manner in which changes are brought about due to pollution*

Unit – I **Chemistry for Environment**

Fundamentals of environmental chemistry: Mole Concept, Solution chemistry, solubility product, Solubility of gases, Phase change thermodynamics, Electrochemistry and redox reactions, Gibbs'free energy; Chemical potential; Chemical kinetics and chemical equilibrium. Sources of natural and artificial radiations: Dosimetry, radioactive substances, applications and handling of isotopes and other radionuclides in environment.

Unit – II **Air Chemistry**

Atmospheric chemistry: Composition of air, Chemical speciation, particles, ion and radicals, Formation of particulate matter, Photochemical reactions in the atmosphere, Chemistry of airpollutants, Photochemical smog, Acid rain, Chemistry of Ozone layer depletion and Global warming, Thermal Pollution.

Unit – III **Water Chemistry**

Aquatic chemistry: Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, carbonates, redox potential, Pourbiax diagram.

Unit – IV **Soil & Geochemistry**

Chemistry of Soil: Physio-chemical composition of soil, humus, Inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, Cation exchange capacity(CEC), Reactions in soil solution, Ion exchange (Physiosorption), Ligand exchange (Chemisorption), Complexations, Chelation; Precipitation / dissolution. Environmental geochemistry: Concept of major, trace and REE. Classification of trace elements, Mobility of trace elements, Geochemical cycles. Biochemical aspects of Arsenic, Cadmium, Lead, Mercury, Carbon monoxide, O_3, PAN, MIC and other carcinogens.

Learning Outcomes

On completion of the course, the student will be able to:

- *develop concepts of basic chemistry associated with toxicology of environmental pollutants*
- *outline fundamental and applied aspects of environmental analytical chemistry*
- *apply analytical tools to determine and measure pollutants in various environmental samples*

Recommended Books:

1. Standard methods of chemical analysis, volume 3, part-B, F.J. Welcher.
2. Cosmetics by W.D. Poucher (Three volumes)
3. Insight into speciality inorganic chemicals by D. Thomson, the royal society of chemistry (1995)
4. Industrial water pollution control by W.W. Ecken and elder, Tata McGraw-Hill (2000)
5. Applied chemistry, a text book for Engineers and technologists by H.D. Gesser.
6. Handbook of Industrial chemistry, by Davis Berner.
7. Air pollution by Rao and Rao.
8. Standard methods of water and waste water analysis by A.K. De.

9. Standard Methods of Chemical Analysis, Sixth Edition, Volume two-Part B Frank J. Welcher
10. Quantitative analysis by vogels.
11. Manahan, S. E. (2008). Fundamentals of Environmental Chemistry, 3rd Edition, CRC, Press, USA.
12. Connell D. W. (2005). Basic concepts of Environmental Chemistry 2nd Edition, CRC, Press, USA.
13. Girard J. (2010). Principles of Environmental Chemistry 2nd Edition, James & Barlett, Publishers, USA.

Course Code:	MSCM407	L	T	P	**Credits**
Course Name:	Dissertation/Practical	0	2	4	**6**

Course Outline:

The course is aimed to give student an opportunity to gain in-depth knowledge and use adequate methods in the major subject/field of study. It will allow them to create, analyse and critically evaluate different technical / research solution. Student will learn to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings. Student can identify the issues that must be addressed within the framework of the specific dissertation as means for path forward and student shall also be consciousness of the ethical aspects related to presentation of technical/research dissertation.

Aim of the Course:

After completing this course student will be able to:

- *carry out extensive research and development project or technical project at place of work through problem and gap identification, development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings in context of national and international research.*
- to display the knowledge and capability required for independent work

Unit – I Literature review & identification of research topic

Unit – II Experimental Work to be carried out

Unit – III Report submission & Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, presentations and experimental works to find out a solution to an identified chemistry problem. Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the identified chemistry problem students will be allowed to carry out research work independently.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Recommended Books:

Books from the above courses, recommended as per the topic selected

Course Code:	MSCM408	L	T	P	**Credits**
Course Name:	Comprehensive Viva – voice	0	2	0	2

Course Outline:

The course is aimed to give student an opportunity to identify and understand assumptions and arguments that exist in the national and international literature in the identified area of chemistry. Course will allow student evaluate and synthesize evidence in order to draw conclusions based in research gaps.

Aim of the Course:

After completing this course student will be able to:

- gain skills of collecting, interpreting and presenting information of interest through seminar and report presentation
- ask meaningful questions and originate plausible research and technical gaps and the implications of the expected outcomes.

Unit – I Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, and presentations.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Recommended Books:

Books from the above courses, recommended as per the topic selected

2nd Year, Organic Chemistry

Course Code:	MSCM301	L	T	P	**Credits**
Course Name:	Organic Chemistry –III	4	0	2	6
Theory					

Course Outline:

The course is formulated to learn the fundamentals of organic reaction meachanism,radicals in organic synthesis, some stereochemical aspects. It also includes the importance and basics of photochemistry .

Aim of the Course:

After completing this course student will be able to:

- *learn the fundamentals of Organic reaction mechanism.*
- *know the application of stereochemistry and photochemistry.*

Unit – I	Organic Reaction Mechanism- Alkylation of Nucleophilic Carbon Intermediates: Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. Alkylation of aldehydes, ketones, esters, amides and nitriles. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction). Reaction of carbon nucleophiles with carbonyl groups: Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction and Robinson annulation. Addition reactions with amines and iminium ions; Mannich reaction. Amine catalyzed condensation reaction: Knoevenagel reaction. Acylation of carbanions.
Unit – II	Radicals in organic synthesis - Introduction: Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals. Radical Initiators: azobisisobutyronitrile (AIBN) and dibenzoyl peroxide. Characteristic reactions - Free radical substitution, addition to multiple bonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity),radical cyclizations, autoxidations: synthesis of cumene hydroperoxide from cumene. Radicals in synthesis: Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds. Oxidative coupling, C-C bond formation in aromatics: SRNAr reactions. Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation.
Unit – III	Stereochemistry-I - Classification of point groups based on symmetry elements with examples (nonmathematical treatment). Conformational analysis of medium rings: Eight to ten membered rings and their unusual properties, I-strain, transannular reactions. Stereochemistry of fused ring and bridged ring compounds: decalins, hydrindanes, perhydroanthracenes, steroids, and Bredt's rule. Anancomeric systems, Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones (with $LiAlH_4$, selectride and MPV reduction) and oxidation of cyclohexanols.
Unit – IV	Photochemistry - Principles of photochemistry: quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process. Photochemistry of carbonyl compounds:$\pi \rightarrow \acute{\pi}^*$, $n \rightarrow \acute{\pi}^*$ transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi

	reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction. Photochemistry of olefins: cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di- π- methane rearrangement including aza-di- π -methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation of alkenes. Photochemistry of arenes: 1, 2- , 1, 3- and 1, 4- additions. Photocycloadditions of aromatic Rings. Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions. Chemiluminescence.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. March's Advanced Organic Chemistry, Jerry March, sixth edition, 2007, John Wiley and sons.
2. A guide to mechanism in Organic Chemistry, 6th edition, 2009, Peter Sykes, Pearson education, New Delhi.
3. Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002).
4. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press (2001).
5. Pericyclic reactions, Ian Fleming, Oxford university press, 1999.
6. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.

Practical

Course Outline:

The practical course lay emphasis on separation & identification of mixtures containing three components, preparation & characterization of different organic molecules involving several stages, quantitative analysis of nitrogen, sulphur, halogen & different practicals involving use of steam distillation, TLC & column chromatography.

1. Separation and identification of organic mixtures containing up to three components.
2. Preparation of organic compounds involving several stages, characterization of intermediates and final products
3. Techniques of organic chemistry: Special practical's involving distillation, and thin layer and column chromatography etc.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM302	L	T	P	**Credits**
Course Name:	Organic Chemistry – IV	4	0	2	**6**

Course Outline:

The course adds different type of organic reaction mechanism used in organic synthesis.It involves the basic information and detailed study of about pericyclic reactions and organic synthesis of metals and non-metals.A role of enamines and ylides is reflected in organic synthesis.

Aim of the Course:

After completing this course student will be able to:

- *understand the various kind of reaction mechanism.*
- *Detailed study of pericyclic reaction and photochemistry.*

Unit – I	Name reactions with mechanism and application- Mukaiyama esterification, Mitsonobu reaction, Darzen's Glycidic Ester syntheis, Ritter reaction, Yamaguchi esterification, Peterson olefination. Domino reactions: Characteristics; Nazerov cyclization, Multicomponent reactions: Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis, Click Reactions: Characteristics; Huisgen 1,3-Dipolar Cycloaddition
Unit – II	Pericyclic reactions- Pericyclic reactions: Classification of pericyclic reactions; thermal and photochemical reactions. Three approaches: Evidence for the concertedness of bond making and breaking Symmetry-Allowed and Symmetry-Forbidden Reactions – The Woodward-Hoffmann Rules-Class by Class The generalised Woodward-Hoffmann Rule Explanations for Woodward-Hoffmann Rules The Aromatic Transition structures [Huckel and Mobius] Frontier Orbitals Correlation Diagrams, FMO and PMO approach Molecular orbital symmetry, Frontier orbital of ethylene, 1,3 butadiene, 1,3,5 hexatriene and allyl system. Cycloaddition reactions: Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes. Diels-Alder reactions, 1, 3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, torquoselectivity, site selectivity and effect of substituents in Diels-Alder reactions. Other Cycloaddition Reactions- [4+6] Cycloadditions, Ketene Cycloaddition, Allene Cycloadditions, Carbene Cycloaddition, Epoxidation and Related Cycloadditions. Other Pericyclic reactions: Sigmatropic Rearrangements, Electrocyclic Reactions, Alder 'Ene' Reactions. Electrocyclic reactions: Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron and allyl systems. Sigmatropic rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations. Cope (including oxyCope and aza-Cope) and Claisen rearrangements. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A.
Unit – III	Metals / Non-metals in organic synthesis - Mercury in organic synthesis: Mechanism and regiochemistry of oxymercuration and demercuration of alkenes, mercuration of aromatics, transformation of aryl mercurials to aryl halides. Organomercurials as carbene transfer reagents. Organoboron compounds: Mechanism and regiochemistry of hydroboration of alkenes and alkynes, asymmetric hydroboration using chiral boron reagents, 9-BBN hydroboration, oxazaborolidine (CBS catalyst) and functional group reduction by diborane. Organosilicons: Salient features of silicon governing the reactivity of organosilicons, preparation and important bond-forming reactions of alkyl silanes, alkenyl silanes, aryl silanes and allyl silanes. β-silyl cations as intermediates. Iodotrimethylsilane in organic synthesis. Silyl enol ethers: Application: As nucleophiles (Michael reaction, Mukaiyama aldol reaction), in ring contraction reactions. Organotin compounds: Preparation of alkenyl and allyl tin compounds;

	application in C-C bond formation, in replacement of halogen by H at the same C atom. Selenium in organic synthesis: Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and seleno acetals as α-C-H activating groups
Unit – IV	Enamines and α-C-H functionalization- Enamines: Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison between enamines and enolates. Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines. Wittig reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination. α-C-H functionalization: By nitro, sulfoxide, sulfone and phosphonate groups: generation of carbanions by strong bases (LDA/n-butyl lithium) and applications in C-C bond formation. Bamford-Stevens reaction, Julia olefination and its modification, Seyferth–Gilbert homologation, Steven's rearrangement.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. March's Advanced Organic Chemistry, Jerry March, sixth edition, 2007, John Wiley and sons.
2. A guide to mechanism in Organic Chemistry, 6th edition, 2009, Peter Sykes, Pearson education, New Delhi.
3. Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002).
4. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press (2001).\
5. Pericyclic reactions, Ian Fleming, Oxford University press, 1999.
6. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
7. 7th Edn, R. T .Morrison, R. N. Boyd, & S. K.

Practical

Course Outline:

The practical course lay emphasis on separation & identification of mixtures containing three components, preparation & characterization of different organic molecules involving several stages, quantitative analysis of nitrogen, sulphur, halogen & different practicals involving use of steam distillation, TLC & column chromatography.

1. Quantitative analysis of (i) sulphur (ii) nitrogen (iii) Halogens
2. Preparation / Estimation.
3. Isolation of some natural products.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM303	L	T	P	**Credits**
Course Name:	Organic Chemistry – V	4	0	2	**6**
Theory					

Course Outline:

The course is an introduction to introduction of heterocyclic compounds,Natural products basically carbohydrate and natural pigments.The study of naming,classification and properties of biomolecules is involved in this course.

Aim of the Course:

After completing this course student will be able to:

- *Understand and synthesize the heteromolecules independently at laboratory scale and try to know their importance.*
- *understand the techniques involved in extraction and methods of determination of structure of natural products.*
- *Gain the knowledge of detaiedl outline of biomolecules.*

Unit – I Heterocycle-I, Nomenclature of heterocyclic compounds of bicyclic/tricyclic (5-6 Membered) fused heterocycles (up to three hetero atoms). (Common, systematic (Hantzsch-Widman) and replacement nomenclature) Nucleophilic ring opening reactions of oxiranes, aziridines, oxetanes and azetidines. Structure, reactivity, synthesis and reactions of coumarins, quinoxalines, cinnolines, indole, benzimidazoles, benzoxazoles, benzothiazoles, Purines and acridines.

Unit – II Natural products-I -Carbohydrates: Introduction to naturally occurring sugars: Deoxysugars, aminosugars, branched sugars. Structure elucidation of lactose and Dglucosamine (synthesis not expected). Structural features and applications of inositol, starch, cellulose, chitin and heparin. Natural pigments: General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of βcarotene and Cyanin (with synthesis). Synthesis of ubiquinone from 3, 4, 5trimethoxyacetophenone. Insect pheromones: General structural features and importance. Types of pheromones (aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of bombykol from acetylene, disparlure from 6-methylhept-1-ene, grandisol from 2-methyl-1, 3-butadiene. Alkaloids: Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of coniine.

Unit – III Biomolecules-I, Amino acids, peptides and proteins: Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, α- helix, βsheets, super secondary structure. Tertiary structure of protein: folding and domain structure. Quaternary structure. Nucleic acids: Structure and function of physiologically important nucleotides (c-AMP, ADP, ATP) and nucleic acids (DNA and RNA), replication, genetic code, protein biosynthesis, mutation. Chemical synthesis of oligonucleotides: Phosphodiester, Phosphotriester, Phosphoramidite and H- phosphonate methods including solid phase approach.

Unit – IV Biomolecules-II, Chemistry of enzymes: Introduction, nomenclature, classes and general types of reactions catalyzed by enzymes. Properties of enzymes: a) enzyme efficiency/ catalytic power b) enzyme specificity; Fischer's 'lock and key' and Koshland 'induced fit' hypothesis.

Concept and identification of active site. Factors affecting enzyme kinetics: Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and irreversible inhibition. Mechanism of enzyme action: transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Mechanism of chymotrypsin catalyzed hydrolysis of a peptide bond.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Natural product chemistry, A mechanistic, biosynthetic and ecological approach, Kurt B.G. Torssell, Apotekarsocieteten – Swedish Pharmaceutical Press.
2. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
3. Heterocyclic chemistry, 3rd edition, Thomas L. Gilchrist, Pearson Education, 2007.
4. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley Eastern Ltd., 1990.
5. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.

Practical

Course Outline:

The practical course lay emphasis on separation & identification of mixtures containing three components, preparation & characterization of different organic molecules involving several stages, quantitative analysis of nitrogen, sulphur, halogen & different pra cticals involving use of steam distillation, TLC & column chromatography.

1. Interpretation of spectral charts.
2. Determination of iodine value by Wij solution.

Any other experiment can be carried out in class/ Laboratory

Course Code:	MSCM304	L	T	P	**Credits**
Course Name:	Computer Application in Chemistry	4	0	0	**4**
Theory					

Course Outline:

This Course provides the knowledge of utilization of computers in field of chemistry.Chemistry and chemical engineering, like many other disciplines, are being profoundly influenced by increased computing power.The small applications developed in programming aims to produce results for given values of constants and for observed values of inputs for various experiments from curriculum.

Aim of the Course:

After completing this course student will be able to:

- *explain the importance of computers application in chemistry.*
- *acquire competency to use chemistry related software.*

Unit – I Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

Unit – II *Roots of equations:* Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.

Unit – III *Differential calculus:* Numerical differentiation. *Integral calculus:* Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values. *Simultaneous equations:* Matrix manipulation: addition, multiplication. Gauss-Siedal method.

Unit – IV *Interpolation, extrapolation and curve fitting:* Handling of experimental data. *Conceptual background of molecular modelling:* Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. A.L. Lehninger, Principles of Biochemistry, (1992) CBS Publishers, Delhi.
2. D. Voet, J.G. Voet& CW Pratt, Fundamentals of Biochemistry, (1999) John Wiley & Sons, New York.
3. H.R. Mahler and E.H. Cordes, Biological Chemistry, 2nd Edition, (1971) Harper and Row Pub., New York.
4. T.C. Bruice and S. Bentkovic, Bioorganic Mechanisms, Vol. I & II, (1966) W. A. Benjamin, New York.
5. H. Dugas and C. Penney, Bioorganic Chemistry: A Chemical Approach to Enzyme Action, (1981) Springer- Verlag, New York.
6. C. Walsh, Enzymatic Reaction Mechanisms, W.H. Freeman & Co., New York.

Course Code:	MSCM305	L	T	P	**Credits**
Course Name:	**Research Methodology and Scientific Communication Skills**	4	0	0	**4**

Course Outline:

This course is an applicative course and gives an insight to the working in research. Through this course students shall gain exposure to the different techniques and methods used in historical science .It enhances communication skill process in science web.

Aim of the Course:

After completing this course student will be able to:

- *To generate Curiosity about some ideological research work..*
- Gain effective and interactive technical communication skill in science field.

Unit – I History of science and science methodologies: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology. Choosing a mentor, lab and research question; maintaining a lab notebook. Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Unit – II Process of communication

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit – III Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non- blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct

Unit - IV Chemical Safety and Ethical Handling of Chemicals:

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and

transportation of hazardous chemicals.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based class room assignment will also be a part of learning activity.

Recommended Books:

9. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011)
10. Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
11. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
12. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
13. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
14. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
15. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
    OSU safety manual 1.01.

Course Code:	MSCM306	L	T	P	**Credits**
Course Name:	Summer Internship	0	0	2	2
Course Outline: This course will allow student to understand requirements and gain confidence to develop work culture in an Industry. Student will develop knowledge of application of chemistry concepts and principles.					

Unit I Project conduct at Industry / R&D / etc.

Unit II Report Preparation and Submission

Unit III Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, experimental work at Industry / R&D / etc. and presentations.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Semester IV (Organic Chemistry)

Course Code:	MSCM401	L	T	P	**Credits**
Course Name:	Organic Chemistry – VI	4	0	0	4
Theory					

Course Outline:

The course is an introduction to stereochemical features of steroids,vitamins including the synthesis of water soluble and fat soluble vitamins and their synthesis. It consists the role of antibiotics and naturally occuring insectisides.itmanuplates the information about the important separation technique i.e. ^{13}**C**.

Aim of the Course:

After completing this course student will be able to:

- *understand and appreciate the concept of steroids and vitamins*
- *understand the design of oraganic synthesis.*

Unit – I **Steroids** : General structure, classification, Occurrence, biologicalrole, important stucturaland stereochemical features of the following: corticosteroids, steroidal hormones,steroidal alkaloids, sterols and bile acids. Synthesis of 16-DPA from cholesterol and plant sapogenin Synthesis of the following from 16-DPA:andosterone,testosterone, oestrone, oestriol,oestradiol and projesterone. Synthesis of cinerolone, jasmolone, allethrolone, exaltone and muscone.

Unit – II **Vitamins :** Classification , sources and boilogical importance of vitamin B_1,B_2,B_6, folic acid, B_{12},C,D_1,E (α-tocopherol) ,K_1,K_2 ,H (β- biotin), Synthesis of the following :Vitamin B_1 including synthesis of pyrimidine and thiazole moities Vitamin B_2 from 3,4-dimethyl aniline and D(-) ribose Vitamin B_6 from : 1) ethoxyacetylacetone and cyanoacetamide Ethyl ester of N- formyl - DL-alanine (Harn's synthesis) Vitamin E (α-tocopherol) from trimethylquinol and phytyl bromide Vitamin K_1 from 2-methyl-1,4-naphthaquinone and phytol. **Antibiotics :** Classification based on the basis of activity, structure elucidationof penicillin-G and cephalosporin C. Synthesis of penicillin-G and phenoxymethylpenicillin from D - penillamine and t- butyl phthalimide malonaldehyde (synthesis of D- penicillamine and t-butyl phthalimide malonaldehyde expected) **Naturally occurring insecticides :** Sources, structure and biological properties of pyrethrums (pyrethrin I), rotenoids (rotenone), azadirachtin. Synthesis of pyrethrin I

Unit – III ^{13}**C - NMR spectroscopy :** Introduction ^{13}**C -** chemical shifts, calculation of ^{13}**C** -chemical shifts,proton couples ^{13}**C** -spectra. Proton decoupled ^{13}**C .**Off resonance decoupling, DEPT technique heteronuclear coupling of carbon to ^{19}F, ^{31}P.**Two - dimensional NMR spectroscopy :** Introduction COSY and HETCOR techniques(including interpretation of COSY and HETCOR spectra) NOESY and ROESY techniques **Problem :** Based on combined use of spectroscopic techniques /advanced techniques. **ESR and Fluorescence spectroscopy :** Principles and applications. Application of NMR in medicine.

Unit – IV Designing of oraganic synthesis : Protection and de-protection of hydroxyl, amino, carboxyl,ketone and aldehyde functions as illustrated in the synthesis of polypeptide and polynucleotide, enamines, Umpolung in organic synthesis Retrosynthesis.Principles and applications of aymmetric synthesis: Stereoselectivity in cyclic compounds,enantio-selectivity,diastereo-selectivity. Enantiometric and diastereomeric excess, stereoselective aldol reactions.Cram's rule. Felkin Anh rule. Cram's chelate model. Asymmetric synthesis.use of chiral auxiliaries. Chiral reagents and catalyst,asymmetric hydrogenataion,asymmetric

epoxidation and asymmetric dihydroxylation Synthesis of some complex molecules: synthetic routes based on retrosynthetic analysis for following molecules: prostaglandin A_2 ,atropine and camphor.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
2. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991.
3. Organic Spectroscopy: Principles And Applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004.
4. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.

Course Code:	MSCM402	L	T	P	**Credits**
Course Name:	Organic Chemistry – VII	4	0	0	**4**
Theory					

Course Outline:

The course conveys the chiron approach and rerosynthetic strategy and synthesis of some compounds.It also includes the information of drugs (chiral also),their targets, and their effects.

Aim of the Course:

After completing this course student will be able to:

- *understand the importance of chiron approach.*
- *understand and learn the concept of Biogenesis.*

Unit – I **Chiron approach -** Introduction, The concept of chiral templates and chirons wherein the carbon skeletonis the chiral precursor, Utilization of the basic concepts for rerosynthetic strategy and synthesis of the following- (S) Propanediol, (R) and (S) - Epichlorohydrin. L(+) - Alanine. (-) Multistratin.(-) Pentenomycin.(-) Shikimic acid

Unit – II **Introduction to drugs,their action and discovery,** Relation of drug structure and its chemical and biological properties, Structure,activity and quantitative relationship, Drug targets, Antimicrobial drugs, Antibactaerials : Discovery and developement of penicillins,Cephalosporins,Suiphones and sulphonamides,Teracyclins, Macrolides Polypeptides,Chloromycetin, Antifungals : Fungal Diseases and anti-fungal agents, Antivirals : Viral diseases and anti-viral drugs, Anti-protozoals : Anti-malarials, Anti-amoebic

Unit – III Introduction of chiral drugs,Eutomer, Distomer and eudesmic ratio Distomers- a) with no side effects b) with undesirable side effects synthesis andpharmacological activity of S-Ibuprofen. S-Metaprolol.Ininvir sulfate. Dextropropoxyphen.(+) Ephedrine.Gresiofulvin.R-Indacrinnone,hydrochloride,S-S-captopril Structure and stereochemistry of Hardwickiic acid,Camptothecin and podophyllotoxin Synthesis of Taxol Estrone and Mifepristone Juvabione (K.Mori and Matsui,Pawson and Cheung Synthesis) Fredericamycin A

Unit – IV Biogenesis - The building blocks and construction mechanism of Terpenoids- Mono,Sesqui,Dt and Triterpenoids and cholesterol Alkaloids derived from ornithine,lysine,nicotinic acid,tyrosine and tryptophan. The shikimate pathway-cinnamic acids,lignans and lignin,coumarins, flavonoids and stilbens, isoflavanoids and terpenoid quinones. Synthesis and application of the following drugs : Fluoxetine, oxyphenbutazone, cetrizine, esomeprazole, fluconazole, zidovudine, methotrexate, diclofenac, labetalol, fenofibrate.

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers.

3. Voet, D. and J. G. Voet (2004) Biochemistry, 3rd Edition, John Wiley & sons, Inc. USA.
4. Heterocyclic chemistry, 3rd edition, Thomas L. Gilchrist, Pearson Education, 2007.
5. 8. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley Eastern Ltd., 1990.

Course Code:	MSCM403	L	T	P	**Credits**
Course Name:	Organic Chemistry – VIII	4	0	0	**4**
Theory					

Course Outline:

The course is designed to give inputs about Supramolecular chemistry Recapitulation of Mass spectrometry, Proton NMR spectroscopy and detection of organic compounds by such spectroscopic techniques.

Aim of the Course:

After completing this course student will be able to:

- *understand the nature of addition in pericyclic reactions.*
- *understand the spectroscopic techniques involved in organic chemistry.*

Unit – I Supramolecular Organic Chemistry: Introduction, host-guest interactions, classification of host-guest compounds, intermolecular forces, nature of supramolecular interactions, molecular recognition, chiral discrimination, molecular receptors and design principles, template effect, biomimetic chemistry, cryptands, cyclodextrins, calixarenes, catenanes and rotaxanes, molecular capsules, molecular self-assembly.

Unit – II Pheromones: Introduction and applications, total synthesis of 3,11-dimethyl-2- nonacosanone and its 29-hydroxy derivative, grandisol, exobravicomine, frontaline and juvenile hormone. Introduction to plant hormones: structure determination and synthesis of auxins. Prostaglandins: Introduction. Occurance, nomenclature, classification and physiological effects, synthesis of PGE2 and PGF2$\propto$, biosynthesis and biological importance.

Unit – III Mass spectrometry: Molecular ion peak, base peak, isotopic abundance, metastable ions. Nitrogen rule, Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect. Structure determination involving individual or combined use of the above spectral techniques.

Unit – IV Proton NMR spectroscopy: Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (A2, AB, AX, AB2, AX2, AMX and A2B2-A2X2 spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and Coupling in aromatic and heteroaromatic systems), Temperature effects, Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents. ^{13}C –NMR spectroscopy: Recapitulation, equivalent and non-equivalent carbons (examples of aliphatic and aromatic compounds), ^{13}C- chemical shifts, calculation of ^{13}C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to ^{19}F and ^{31}P. Spectral problems based on UV, IR, ^{1}HNMR and ^{13}CNMR and Mass spectroscopy .

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study.
- Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.

2. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991.
3. Organic Spectroscopy: Principles And Applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004.
4. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.

Course Code:	MSCM404	L	T	P	**Credits**
Course Name:	Analysis and Characterization of Polymers	4	0	0	**4**
Theory					

Course Outline:

This course is an applicative course and gives an insight to the working in a Polymer industry. Through this course students shall gain exposure to the different techniques and methods used in polymer chemistry as well as its several levels of applications in our daily life.

Aim of the Course:

After completing this course student will be able to:

- *explain the general properties and importance of polymers which are widely used.*
- *understand the industrial application of polymers.*

Unit – I Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems. Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Unit – II Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships. (M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.Polydispersity index. Free volume theory, WLF equation, Factors affecting glass transition temperature (T_g).

Unit – III Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

Unit – IV Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual clarity and understanding of the basic concepts of subject area.
- Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the lectures and practical exercises students will be given some topics for self study. Interactive sessions such as theme based on quiz will also be a part of learning activity.

Recommended Books:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
3. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.

4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford
7. University Press.
8. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan(2010).
9. Kemp, W. Organic Spectroscopy, Palgrave.
10. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.

Course Code:	MSCM405	L	T	P	**Credits**
Course Name:	Organic Chemistry IX	4	0	0	**4**
Theory					

Course Outline:

This course involves the basics of heterocyclic compounds, Drug discovery, design and development .It also provides information of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. The course will survey key aspects of green chemistry in modern research and development both in academia and industry, as well as relevant implications for the environment, technology, and public policy.

Aim of the Course:

After completing this course student will be able to:

- *understand the how to design drugs by synthetic pathway*
- *understand the concept of green chemistry and learn the techniques involved in green chemistry*

Unit – I Heterocyclic compounds-II, Heterocyclic compounds: Introduction, classification, Nomenclature of heterocyclic compounds of monocyclic (3-6 membered) (Common, systematic (Hantzsch-Widman) and replacement nomenclature) Structure, reactivity, synthesis and reactions of pyrazole, imidazole, oxazole, isoxazole, thiazole, isothiazole, pyridazines, pyrimidine, pyrazines and oxazines. pyridines, pyridine-N-oxide, pyridazines, s-titrazines,quinolines,isoquinolines,indoles,purines,oxazines,coumarins.

Unit – II Drug discovery, design and development, Introduction, important terms used in medicinal chemistry: receptor, therapeutic index, bioavailability, drug assay and drug potency. General idea of factors affecting bioactivity: Resonance, inductive effect, bioisosterism, spatial considerations. Basic pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H-bonding, partition coefficient and isomerism in drug distribution and drug-receptor binding. Procedures in drug design: Drug discovery without a lead: Penicillin, Librium. Lead discovery: random screening, non-random (or targeted) screening. Lead modification: Identification of the pharmacophore, Functional group modification. Structure-activity relationship, Structure modification to increase potency and therapeutic index: Homologation, chain branching, ring-chain transformation, bioisosterism, combinatiorial synthesis (basic idea).

Unit – III Beckmann, Hofmann, Curtius, Schmidt, Wolf, Lossen, Baeyer – Villiger, Sommelet, Favorskii, Pinacole – Pinacolone, Benzil – Benzillic acid, Claisen and Cope Rearrangements, Fries Migration.

Unit – IV Green chemistry- Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts. Use of the following in green synthesis with suitable examples: a) Green reagents: dimethylcarbonate, polymer supported reagents. b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts.
c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical

Modes of Learning Engagements:

- The course is visualized to be conducted through series of lectures for the conceptual

understanding of the basic concepts of phytochemistry.

- Lectures from subject specialists will be conducted to enlighten the students on topics of phytochemistry.
- Based upon the lectures and practical exercises students will be given assignment work.

Recommended Books:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
2. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991.
3. Organic Spectroscopy: Principles And Applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004.
4. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
5. Green Chemistry: An Introductory Text, 2nd Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.

Course Code:	MSCM406	L	T	P	**Credits**
Course Name:	Environmental Analytical Chemistry	4	0	0	**4**

Course Outline:

This course is an Introduction to Environmental chemistry and study of environmental pollutants.

Aim of the Course

After completing this course student will be able to:

- *understand various aspects of air, water and soil chemistry.*
- *relate chemical constituents present in the environment, interactions between them and manner in which changes are brought about due to pollution*

Unit – I **Chemistry for Environment**

Fundamentals of environmental chemistry: Mole Concept, Solution chemistry, solubility product, Solubility of gases, Phase change thermodynamics, Electrochemistry and redox reactions, Gibbs'free energy; Chemical potential; Chemical kinetics and chemical equilibrium. Sources of natural and artificial radiations: Dosimetry, radioactive substances, applications and handling of isotopes and other radionuclides in environment.

Unit – II **Air Chemistry**

Atmospheric chemistry: Composition of air, Chemical speciation, particles, ion and radicals, Formation of particulate matter, Photochemical reactions in the atmosphere, Chemistry of airpollutants, Photochemical smog, Acid rain, Chemistry of Ozone layer depletion and Global warming, Thermal Pollution.

Unit – III **Water Chemistry**

Aquatic chemistry: Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, carbonates, redox potential, Pourbiax diagram.

Unit – IV **Soil & Geochemistry**

Chemistry of Soil: Physio-chemical composition of soil, humus, Inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, Cation exchange capacity(CEC), Reactions in soil solution, Ion exchange (Physiosorption), Ligand exchange (Chemisorption), Complexations, Chelation; Precipitation / dissolution. Environmental geochemistry: Concept of major, trace and REE. Classification of trace elements, Mobility of trace elements, Geochemical cycles. Biochemical aspects of Arsenic, Cadmium, Lead, Mercury, Carbon monoxide, O_3, PAN, MIC and other carcinogens.

Learning Outcomes

On completion of the course, the student will be able to:

- *develop concepts of basic chemistry associated with toxicology of environmental pollutants*
- *outline fundamental and applied aspects of environmental analytical chemistry*
- *apply analytical tools to determine and measure pollutants in various environmental samples*

Recommended Books:

1. Standard methods of chemical analysis, volume 3, part-B, F.J. Welcher.
2. Cosmetics by W.D. Poucher (Three volumes)
3. Insight into speciality inorganic chemicals by D. Thomson, the royal society of chemistry (1995)
4. Industrial water pollution control by W.W. Ecken and elder, Tata McGraw-Hill (2000)
5. Applied chemistry, a text book for Engineers and technologists by H.D. Gesser.
6. Handbook of Industrial chemistry, by Davis Berner.
7. Air pollution by Rao and Rao
8. Standard methods of water and waste water analysis by A.K. De.

9. Standard Methods of Chemical Analysis, Sixth Edition, Volume two-Part B Frank J. Welcher
10. Quantitative analysis by vogels.
11. Manahan, S. E. (2008). Fundamentals of Environmental Chemistry, 3rd Edition, CRC, Press, USA.
12. Connell D. W. (2005). Basic concepts of Environmental Chemistry 2nd Edition, CRC, Press, USA.
13. Girard J. (2010). Principles of Environmental Chemistry 2nd Edition, James & Barlett, Publishers, USA.

Course Code:	MSCM407	L	T	P	**Credits**
Course Name:	Dissertation/Practical	0	2	4	**6**

Course Outline:

The course is aimed to give student an opportunity to gain in-depth knowledge and use adequate methods in the major subject/field of study. It will allow them to create, analyse and critically evaluate different technical / research solution. Student will learn to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings. Student can identify the issues that must be addressed within the framework of the specific dissertation as means for path forward and student shall also be consciousness of the ethical aspects related to presentation of technical/research dissertation.

Aim of the Course:

After completing this course student will be able to:

- *carry out extensive research and development project or technical project at place of work through problem and gap identification, development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings in context of national and international research.*
- to display the knowledge and capability required for independent work

Unit – I Literature review & identification of research topic

Unit – II Experimental Work to be carried out

Unit – III Report submission & Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, presentations and experimental works to find out a solution to an identified chemistry problem. Certain practical exercises will be designed to grasp the concepts completely.
- Based upon the identified chemistry problem students will be allowed to carry out research work independently.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Recommended Books:

Books from the above courses, recommended as per the topic selected

Course Code:	MSCM408	L	T	P	**Credits**
Course Name:	Comprehensive Viva – voice	0	2	0	2

Course Outline:

The course is aimed to give student an opportunity to identify and understand assumptions and arguments that exist in the national and international literature in the identified area of chemistry. Course will allow student evaluate and synthesize evidence in order to draw conclusions based in research gaps.

Aim of the Course:

After completing this course student will be able to:

- gain skills of collecting, interpreting and presenting information of interest through seminar and report presentation
- ask meaningful questions and originate plausible research and technical gaps and the implications of the expected outcomes.

Unit – I Presentation

Modes of Learning Engagements:

- The course is visualized to be conducted through series of tutorials, discussions, literature review, and presentations.
- Interactive sessions such as group discussion, seminars, conferences and workshops will also be a part of learning activity.

Recommended Books:

Books from the above courses, recommended as per the topic selected