MSc-CHEMISTRY
(Under CBCS)
FIRST YEAR 2017-18
TWO SEMESTERS: 15 WEEKS EACH

TEACHING AND EXAMINATION SCHEME OF FIRST SEMESTER

CORE COURSE:

CODE	DESCRIPTION	HRS/W	HRS/SEM	EXAM	CCA	ESE	TOTAL
MSCH111	**Group Theory & Chemical Bonding**	4	60	3 HRS	30	70	100
MSCH112	**Organic Chemistry-I**	4	60	3 HRS	30	70	100
MSCH113	**Physical Chemistry-I**	4	60	3 HRS	30	70	100
MSCH114	**Analytical Chemistry-I**	4	60	3 HRS	30	70	100
Total Theory							**400**
MSCH121	**Laboratory Course I: Inorganic Chemistry**	9	135	12HRS	30	70	100
MSCH122	**Laboratory Course II: Physical Chemistry**	6	90	6 HRS	15	35	50
Total Practical							**150**
Grand Total							**550**

Note:

1. A board of two examiners (**one internal and one externa**l) will be appointed for conducting the examination of each laboratory course.
2. In practical exam one major and minor experiment will be allotted in each lab course.
3. In inorganic mixture student can consult book for basic radicals after reporting the concern groups.
4. In organic mixture student can consult book for confirmatory test of the compounds after reporting the initial physical properties, element detection, functional group & melting/boiling point of the compound.
5. Practical Exam shall be conducted in two days where ever required(12 Hours)

SKILL BASED COURSE IN CHEMISTRY FOR CHEMISTRY STUDENTS:

STUDENT HAVE TO OPT ONE SKILL BASED PAPER FROM EITHERPAPER: SKCH131(A) or (B).

CODE	DESCRIPTION	THEORY		PRACTICALS	
		HRS/W	HRS/SEM	HRS/W	HRS/SEM
SKCH131(A)	**Cosmeticology And Cosmetic Preparation-I**	2	30	2	30
SKCH132(B)	**Technology Of Dyes**	2	30	2	30

MSCH111- GROUP THEORY & CHEMICAL BONDING		
Unit 1	**Stereochemistry and bonding in main group compounds** VSEPR, Walsh Diagrams of tri, tetra and penta atomic molecules, dπ-pπ bonds, Bent's rule and energetics of hybridization, some simple reactions of covalently bonded molecules: atomic inversion, berry pseudorotation, substitution reactions and free radical reactions.	**15 HRS**
Unit 2	**Metal Ligand Bonding** Limitations of Crystal field theory, molecular orbital theory: octahedral, tetrahedral and square planar complexes, π- bonding and molecular orbital theory, explanation of position of the ligands in Spectrochemical series using MOT, Comparison with CFT.	**15 HRS**
Unit 3	**Molecular Symmetry and Symmetry Groups:** Symmetry elements and operations, proper axis of symmetry & rotation, symmetry planes & reflection, center of symmetry & inversion, improper axis of symmetry & improper rotation and identity. **Definition and Theorems of Group Theory:** Defining properties of Group, subgroup and classes; group multiplication tables. **Molecular Point Groups:**Identification of molecular point groups, molecules of low, high & special symmetry, molecules containing multiple higher order axes, Schonflies symbols, systematic assignment of point groups. Descent in symmetry with substitution.	**15 HRS**
Unit 4	**Matrix Methods in Symmetry** Introduction to matrices, types of matrices, equal matrices, matrix mathematics, block factorization of large matrices, transformation matrices. Representations of groups by matrices (representation for the Cn, Cnv, Cnh, Dnh etc. groups to be worked out explicitly). Reducible and irreducible representations, Character of a representation. Great Orthogonality Theorem (without Proof) and its Importance. Construction of character tables, character tables of C2v, C3v and C4v point groups, Mulliken symbols for IRs and structure of character table. Standard reduction formula for reduction of reducible reprsenttion, direct products.	**15 HRS**
Unit 5	**Symmetry and Chemical bonding:** Orbital symmetries & overlap, hybridisation scheme in Linear, trigonalplanar, tetrahedral, squarepyramidal& trigonal pyramidal; molecules with π bonding as in trigonal planar, tetrahedral, octahedral& benzene	**15 HRS**

Suggested Readings:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huhey, Pearson.
3. Inorganic Chemistry, Shriver and Atkins, Oxford University Press
4. Modern Inorganic Chemistry, William L. Jolly, Tata McGraw Hill
5. Concepts and Models of Inorganic Chemistry, Bodie E. Douglas and Darl H. McDaniel, Oxford
6. Inorganic Chemistry, GeryWulfsberg, Viva
7. Chemistry of the Elements, N.N.Green Wood and A. Earnshow, Elsevier.
8. Inorganic Chemistry, James E house, Elsevier.
9. Chemical Applications of Group Theory. F.A. Cotton
10. Molecular Symmetry and Group Theory, Robert L Carter, John Wiley & Sons
11. Symmetry andSpectroscopy of Molecules, K Veera Reddy, New Age
12. Advanced Inorganic Chemistry, Asim K Das

MSCH112-ORGANIC CHEMISTRY-I		
Unit 1	**Nature of bonding in Organic Molecules:** **Delocalized chemical bonding:** Conjugation, cross conjugation, resonance hyperconjugation, bonding in fullerenes, tautomerism. **Aromaticity in benzenoid and non-benzenoid compounds:** Alternant and non-alternant hydrocarbons, Huckel's rule, energy level of π-molecular orbitals, annulenes,homoaromaticity, (PMO approach). Bonds weaker than covalent bonds: addition compounds, crown ethercryptants&cyclodextrinsand rotaxanes& their structure.	**15 HRS**
Unit 2	**Stereohemistry I:** **Conformational analysis:** Cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, and steric strain due to unavoidable crowding. Stereochemistry of the compounds containing nitrogen, Sulphur and phosphorus.	**15 HRS**
Unit 3	**Stereochemistry II:** Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diasterotopic atoms, groups and faces, stereospecific and stereoselective synthesis, Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.	**15 HRS**
Unit 4	**Reaction Mechanism:** **Structure and Reactivity:** Kinetic and thermodynamic control of reactions. Hammond's postulate, Curtin-Hammett principal, Potential energy diagrams, transition states and intermediates, methods of determining mechanism, isotope effects, Hard and soft acids and bases, Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes, Effects of structure on reactivity resonance and field effects, steric effect, quantitative treatment , The hammett equation and linear free energy relationship, substituent and reaction constants: Taft equation	**15 HRS**
Unit 5	**Pericyclic Reactions:** Molecular orbital symmetry, frontier orbitals of ethylene, 1, 3-butadiene, 1, 3,5-hexatriene and ally1 system. Classification of pericyclic reactions. Woodward Hoffman correlation diagrams, FMO and PMO approach. **Electrocyclic Reactions: C**onrotatory and disrotatory motions, 4n, 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions. **SigmatropicRearrangemnts:** Suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3, 3 and 5, 5 sigmatropic shifts. Rearrangements, Claisen, Cope andaza-cope rearrangements. Fluxional tautomerism, ene reaction	**15 HRS**

Suggested Readings:

1. Advanced Organic Chemistry-Reactions, Mechanism and structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University press.
5. Organic Chemistry, T.T. Morrison and R.N. Boyd, Prentice-Hall Modern Organic Reactions H.O. House, Benjamin.
6. Principles of Organic Synthesis. R.O.C. Norman and J.M Coxon, Blackie Academic & Professional.
7. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
8. Reaction Mechanism in Organic Chemistry S.M. Mukherji and S.P. Singh. Macmillan.
9. Sterochemistry Organic Compounds, D.N. Asipuri, New Age International.
10. Sterochemistry of organic Compounds, P.S. Kalsi, New Age International.
11. Pericyclic Reactions, Jagdamasingh.

MSCH113-PHYSICAL CHEMISTRY-I		
Unit 1	**Chemical Dynamics I:** Ionic reactions, Kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions. Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde). Photochemical reaction (hydrogen-oxygen and hydrogen-chlorine reactions), decomposition of ethane.	**15 HRS**
Unit 2	**Chemical DynamicsII:** **Fast Reactions:** General features of fast reactions, study of fast reactions by flow method, relaxation method and flash photolysis method, NMR method. Dynamics of molecular motions, probing the transition state, dynamics of barrier less chemical reactions in solution, dynamics of unimolecular reaction, Lindeman, Hinshelwood, RRK and RRKM theories of unimolecular reactions.	**15 HRS**
Unit 3	**Catalysis &enzyme:**Heterogeneous and Homogeneous catalysis, advantages and disadvantages. Catalytic cycles. **Heterogeneous catalysis:** Preparation methods, characterization and quantification of surface active sites, kinetics of heterogeneous catalytic reactions. Structure of adsorbed species. Supported catalysts and metal-support interaction. Catalyst deactivation and regeneration. **Enzyme:** introduction, types and characteristics, kinetics of enzyme reactions	**15 HRS**
Unit 4	**Macromolecules:** Polymer: Definition types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetic of polymerization, mechanism of polymerization. Molecular mass, number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering methods) sedimentation, chain configuration of macromolecules, calculation of average dimensions of various chain structures.	**15 HRS**
Unit 5	**Electrochemistry:** Electrochemistry of solutions: Debye-Huckel-onsagar treatment and its extension, Debye-Huckel-Jerrum mode, ion-solvent interaction, born model. Electro- Kinetic phenomenon and quantitative treatment of Zeta potential. Thermodynamics of electrified interface equations. Derivation of electrocapilary Lippmann equation (surface excess). Structure of electrified interface. Helmholtz, Guoy-chapman and Stern models. Over potentials. Exchange current density, Butler Volmer equation, Tafel plot. Introduction to corrosion, theories, forms of corrosion. Corrosion monitoring and prevention methods.	**15 HRS**

Suggested Readings:

1. Physical chemistry, P.W. Atkins, ELBS.
2. Chemical Kinetics, K.J. Laidler, Megraw-Hill.
3. Kinetics and Mechanism of Chemical Transformation, J. Rajarman and J. Kuriacose, McMillan.
4. Micelles: Theoretical and Applied Aspects, V Moroi, Plenum.
5. Modern Electrochemistry Vol, I and Vol. II, J.O.M. Bockris and A.K.N. Reddy Plenum.
6. Introduction to Polymer Science V.R. Gowarkar, N.V.Vishwananathan and J. Sridhar, Wiley Eastern.
7. Principles and practice of heterogenous catalysis, Thomas J.M. and Thomas M.J., John Wiley
8. Concepts of modern catalysis and kinetics, Chorkendoff I.B. and Niemantsverdriet J.M.

MSCH114-ANALYTICALCHEMISTRY-I		
Unit 1	**Fundamentals of Chemical Analysis:** Classification of analytical method, significance, Sensitivity and Selectivity of Analytical methods, Sampling, Accuracy & precision, Errors: types of errors, error distribution curve, avoid, standard Deviation; Calibration curve and Correlation Coefficient; linear regression; student 't' test, Analysis of Variance (ANOVA). Good lab practices. Quality control, Quality assurance, International standards & government standards in chemical analysis.	**15 HRS**
Unit 2	**Spectroscopic Techniques-I** Basic principles of the spectrophotometry, basic instrumentation: single beam and double beam spectrophotometer. **Flame Photometry & Atomic Absorption Spectroscopy (AAS)**: Principle, General layout of instrument and applications.	**15 HRS**
Unit 3	**Spectroscopic Techniques-II** **Inductively Coupled Plasma Spectroscopy (ICPS):** ICP -AES, ICP-MS, OES, Theory, instrumentation and applications. **Fluorescence Spectroscopy:** Principle, Fluorescence, Phosphorescence basic Instrumentation and their applications. Chemiluminscence. **Nephelometry and Turbidometry:** Principle, instrumentation and applications.	**15 HRS**
Unit 4	**Seperation Technique** **Solvent extraction-** Principle, methodology and applications, Synergistic extraction: determination of nickel, crown ether for ion association complex. Organic reagents like dithiol, diketones, oxinedithizone, cuproin, cupferron, dimethylglyoxime and dithiocarbamates in solvent extraction and electrophoresis	**15 HRS**
Unit 5	**Chromatography:** Introduction. **HPLC:** Theory, General layout of equipment, detector working principle (u.v detector, luminescencedetector, refractive index detectors)and applications. **HPTLC:**Principle, advantage over TLC, mobile and stationary Phase **Gas chromatography:** Theory, General layout of equipment, detectors (Flame ionization, Photoionization detector, coupled GC detector) and applications. **Gas Chromatography –Mass spectrometry**	**15 HRS**

Suggested Readings:

1. Vogel's Textbook of Quantitative Chemical Analysis, G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney, Publ ELBS, Longman, UK
2. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.
3. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler. Pubi WB Saunders.
4. Analytical Chemistry, G.D. Christian, John Willy & Sons.

MSCH121-LABORATORY COURSE-I: INORGANIC CHEMISTRY

I. Qualitative Analysis: Qualitative estimation of the inorganic mixture for six radicals including interfering acid radicals, their combinations and insoluble oxides, sulphates and halides including rare earth elements.

II. Quantitative Analysis:

a. Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Ag etc, involving volumetric and gravimetric methods.

b. Estimation of three constituent in the given mixture (one gravimetrically and one volumetrically and one colorimetrically).

III. Chromatography

a. Separation of cations and anions by circular Paper Chromatography.

MSCH122-LABORATORY COURSE-I: PHYSICAL CHEMISTRY

I. Chemical Kinetics

1. To compare the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of an ester.
2. Determination of the effect of Change in temperature on the rate constant of acid hydrolysis of ester & calculation of activation energy.
3. Determination of the effect of Change of concentration of reactant -and catalyst on the rate of acid hydrolysis of ester.
4. Determination of the effect of Ionic strength of the media on the velocity constant of an acid hydrolysis of an ester.
5. To study the effect of acid strength on the reaction of acetone and iodine.

II. Adsorption: To study the adsorption of acetic acid/oxalic acid by activated charcoal and verification of Freundlich and Langmuir's isotherms.

III. Electrochemistry /Conductometry

1. To determine the strength of weak acid using NaOHconductometrically.
2. To determine the strength of strong and weak acids in a given mixture conductometrically.

IV. Colorimetry:

1. To test the validity of Beer-Lambert law using colorimeter/ spectrophotometer and determination of the unknown concentration of a solution.

Suggested Readings:

1. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman
2. Findley's Practical Physical Chemistry, BP Levitt, Longman.
3. Experimental Physical Chemistry, RC Das and B Behera, Tata McGraw Hill
4. Experimental physical Chemistry by F. Daniel and others (International Student Edition)

5. Advanced Practical Physical Chemistry, JB Yadav, Goel Publishing House.
6. Advanced Experimental Chemistry, Vol. I Physical JNGurtu and R Kapoor, S. Chand & Co.

MSCHSC131(A): COSMETICOLOGY AND COSMETIC PREPARATION-I

THEORY:

Fundamentals of cosmetic science. Classification of cosmetics. Structure and function of skin and hair. Formulation, preparation and packaging of cosmetics for lotion, suspension, vanishing cream, paste, shaving cream, liquid detergent, ointment.

EXPERIMENTS: Topical Preparations

1. To prepare sunscreen calamine suspension.
2. To prepare and submit vanishing cream.
3. To To prepare and submit Calamine lotion
4. To prepare and submit Zinc Sulphate lotion.
5. To prepare and dispense zinc oxide paste.
6. To prepare and dispense shaving cream.
7. To prepare and dispense astringent lotion.
8. Prepare and submit liquid detergent.
9. To prepare and submit boric acid ointment.

SUGGESTED READING:

1. Ansel H. C, Introduction to Pharmaceutical Dosage Forms, K M Varghese and, Bombay.
2. Jellinek J. S., Formulation and Function of Cosmetics, John Wiley and sons, NY.
3. B.M. Mithal, A Handbook of Cosmetics, Vallabh Praakashan Delhi
4. P. P. Sharma, " Cosmetics- formulation, Manufacturing and Quality control" , Vandana Publication, Delhi
5. Indian Pharmacopoeia, I.P., Edition II, Year 1966,
6. Cooper and Guns "Dispensing for Pharmaceutical Students", CBS Publisher, New Delhi

MSCHSC131 (B): TECHNOLOGY OF DYE

THEORY

Introduction, classification of dyes, general idea about the synthesis of different dye intermediates and synthetic dyes (azoic, acidic, basic, disperse, mordent and Sulphur dyes). Dyeing processes of acrylic fibers. Finishes to improve colour fastness, effect of temperature on the dying process, pigment for textile colouration.

PRACTICAL

1. Preparation of methyl orange.
2. Preparation of malachite green.
3. Preparation of natural dye.
4. Effect of mordents and modifiers on the process of dying.(Alizarin red using Fe^{+2} , Mg^{+2},Al^{+3}, Cu^{+})
5. To study the interaction of natural dyes with different fibers.
6. To study the interaction of synthetic dyes with different fibers.
7. To study the optimum PH for dying cotton cellulose fabrics.
8. Testing of dyes.
9. Thin layer chromatography of dyes.

SUGGESTED READING:

1. Synthetic Dyes, Dr. G.R chatwal, Himalaya Publishing House
2. Colours Chemistry: Synthesis, Properties and applications of organic Dyes and pigments, Heinrich Zollinger, Wiley-VCH
3. Synthetic Dyes, O.D Tyagi, M.Yadav , Anmol Publication Pvt Ltd.
4. Industrial chemistry by B.K Sharma.
5. The chemistry and application of Dyes, David R. Waring and GeofferyHallos.

TEACHING AND EXAMINATION SCHEME
SECOND SEMESTERCORE COURSE:

CODE	DESCRIPTION	HRS/W	HRS/SEM	EXAM	CCA	ESE	TOTAL
MSCH211	COORDINATION CHEMISTRY	4	60	3 HRS	30	70	100
MSCH212	ORGANIC CHEMISTRY-II	4	60	3 HRS	30	70	100
MSCH213	PHYSICAL CHEMISTRY-II	4	60	3 HRS	30	70	100
MSCH214	ANALYTICAL CHEMISTRY-II	4	60	3 HRS	30	70	100
Total Theory							**400**
MSC221	LABORATORY COURSE III: ORGANICCHEMISTRY	9	135	12HRS	30	70	100
MSCH222	LABORATORY COURSE IV:ANALYTICALCHEMISTRY	6	90	6HRS	15	35	50
Total Practical							**150**
Grand Total							**550**

Note:

1. A board of two examiners (**one internal and one externa**l) will be appointed for conducting the examination of each laboratory course.
2. In practical exam one major and minor experiment will be allotted in each lab course.
3. In inorganic mixture student can consult book for basic radicals after reporting the concern groups.
4. In organic mixture student can consult book for confirmatory test of the compounds after reporting the initial physical properties, element detection, functional group & melting/boiling point of the compound.
5. Practical Exam shall be conducted in two days where ever required(Hours)

SKILL BASED COURSE IN CHEMISTRY FOR OTHER STUDENTS:

CODE	DESCRIPTION	THEORY		PRACTICALS	
		HRS/W	HRS/SEM	HRS/W	HRS/SEM
MSCHSC231	FUNDAMENTAL CONCEPT IN CHEMICAL CALCULATIONS: STOICHIOMETRY	2	15	2	30

SKILL BASED COURSE OFFERED BY OTHER DEPARTMENTS FOR CHEMISTRY STUDENTS:

STUDENT HAVE TO OPT ANY ONE OF SKILL BASED PAPER FROM SKILL BASED PAPERS OFFERED BY OTHER DEPARTMENTS.

MSCH211-COORDINATION CHEMISTRY		
Unit 1	**Reaction mechanism of Transitions metal complexes** Energy profile of a reaction (transition state or activated complex) nucleophilic and electrophilic substitution, factors responsible for types of substitution reaction. Introductory classical reaction of Henry-Taube in octahedral complexes (inert and labile complexes), classification of mechanism of. Acid hydrolysis, factor affecting acid hydrolysis, base hydrolysis, conjugate base mechanism (S_N1CB) Evidences in favour of conjugate base mechanism, anation reactions, Substitution reaction without metal-ligand bond cleavage (Special reference to Co(III) complexes).	**15 HRS**
Unit 2	**Substitution in square planer complexes:** Trans effect, mechanism of substitution reaction, polarization theory and π bonding theory. **Redox reaction:** Classification of mechanism of octahedral complexes (inner and outer sphere reaction; adjacent attack, remote attack. and bridged outer sphere reaction). Electron transfer reaction, mechanism of one electron transfer reaction: outer sphere reaction, Inner sphere reaction, bridge intermediate mechanism.	**15 HRS**
Unit 3	**Isomerisation and Racemisation Reactions:** Linkage isomerization, geometrical isomerization in square planar and octahedral complexes, racemisation: inter and intramolecular mechanism, isomerisation and racemisation of tris chelates of unsymmetrical chelating ligands, structural changes in complexes containing terdentate ligands, optical isomerisation on tetrahedral complexes and configurational changes in some planar complexes	**15 HRS**
Unit 4	**Electronic spectra of Transition Metal Complexes** Spectroscopic ground states term, correlation, Orgel and Tanabe sugano diagrams for transition metal complexes (d^1 to d^9 states) and calculation of Dq, B and β parameters	**15 HRS**
Unit 5	**Charge Transfer Spectra** General Introduction to charge transfer spectra and types of spectra. Ligand to metal and metal to ligand charge transfer spectra of transition metal complexes. **Magnetic Properties of Transition Metal Complexes:** Anomalous magnetic moments, magnetic exchange coupling and spin crossover. **ORD and CD:** Introduction, assignment of absolute configuration in optically active metal chelates and their configuration	**15 HRS**

Suggested Readings:

1. F.A. Cotton and Wilkinson: Advanced Inorganic Chemistry, John Wiley.
2. J.E. Huhey: Inorganic Chemistry, Harper and Row.
3. N.N.Green Wood and A. Earnshow: Chemisryof the element, Pergamon.
4. A.B.P. Lever: Inorganic Electronic Spectroscopy, Elsevier
5. R.L.Carlin: Magnetochemistry, Verlag.
6. G. Wilkinson, R.D. Gillars and J.A. McLeverty: Comprehensive Coordination Chemistry eds. Pergamon.
7. F. Basolo and R.G. Pearson: Mechanism of Inorganic Reaction, Wiley Eastern.
8. D. Banerjia: Coordination Chemistry, Asian.
9. Advanced Inorganic Chemistry, Asim K Das

MSCH212-ORGANIC CHEMISTRY-II		
Unit 1	**Aliphatic Nucleophilic Substitution** The S_N2, S_N1, mixed S_N1 and S_N2 and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchiomeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system. The SNi mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinlyic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. **Aliphatic Electrophilic Substitution** Bimolecular mechanisms- S_E2 . The S_E1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity	**15 HRS**
Unit 2	**Aromatic Electrophilic Substitution** The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in mono and substituted ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction. **Aromatic NucleophilicSubstitution**:TheSNAr SN1 benzyne and SRN1 mechanisms. Reactivity effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.	**15 HRS**
Unit 3	**Free Radical, Reactions:** Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction and Hunsdiecker reaction	**15 HRS**
Unit 4	**Addition to Carbon-Carbon Multiple Bonds:** Mechanistic and sterochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropanering. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings.Hydroboration. Michaelreaction. Sharpless asymmetric epoxidation. Addition to Carbon-Hetero Multiple Bonds Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitrites. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving enolates Aldol, Knoevenagel, Claisen, Mannish, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters	**15 HRS**
Unit 5	**Elimination Reactions:** The E1, E2 and E1cB mechanisms and their spectrum, stereochemistry of E1 and E2 reactions and elimination from cyclic compounds. Orientation of the double bond. Reactivity effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.	**15 HRS**

Suggested Readings:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall Modern Organic Reactions, H.O. House, Benjamin.
6. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
7. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
8. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.

MSCH213-PHYSICALCHEMISTRY-II		
Unit 1	**Quantum Chemistry** **Introduction to Exact Quantum Mechanical Results:** The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in 1 and 3-dimensional box, the harmonic oscillator, the hydrogen atom.	**15 HRS**
Unit 2	**Quantum Chemistry** **Electronic Structure of Atoms:** Russell-Saunders terms and coupling schemes, spectral terms for p^n configurations and d^n configurations. **Magnetic effects:** Perturbation theoryNormal and anomalous Zeeman effects and Stark effect. **Molecular Orbital Theory:** Huckel molecular orbital (HMO) theory of linear conjugated systems, bond order and charge density calculations. Applications of HMO to ethylene, allyl, butadiene and cyclobutadiene system.	**15 HRS**
Unit 3	**Classical Thermodynamics** **Partial molalproperties:** Partial molar free energy - chemical potential, partial molal volume and partial molal heat content. Gibbs Duhem equation, variation of chemical potential with temperature and pressure, chemical potential for ideal gas. Thermodynamic derivation of law of mass action. Concept of fugacity and determination of fugacity. Thermodynamic derivation of phase rule, application of phase rule to three component systems	**15 HRS**
Unit 4	**Statistical Thermodynamics** Concepts of phase space, microstate and macrostate, Ensemble averaging, Canonical, grand canonical and microcanonical ensembles, Maxwell-Boltzman distribution law (using Lagrange's method of undetermined multipliers). Partition functions translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions- Energy, specific heat at constant volume and constant pressure, entropy, work function, pressure Gibb's free energy and chemical potential. Chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics distribution law and Bose-Einstein statistics distribution law.	**15 HRS**
Unit 5	**Non Equilibrium Thermodynamics** Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g. heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non-equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion, electric conduction	**15 HRS**

Suggested Readings:

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Introduction to Quantium Chemistry, A.K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice Hall.
4. Coulson's Valence, R. McWeeny, ELBS.
5. Physical Chemistry, S. Glasston, Princeton, London.
6. Non Equilibrium Thermodynamics, Fitts, McGraw Hills, New York.
7. Fundamentals of Chemical Thermodynamics, E.N. Yeremin, Mir Publishers

MSCH214: ANALYTICAL CHEMISTRY-II		
Unit 1	**Thermal analysis:** TGA, DSC (differential scanning calorimetry), DTA (differential thermal analysis): principle, methodology and application	**15 HRS**
Unit 2	**Radio analytical Techniques** Radioactive Decay Process-radioactive decay rates, counting statistics, Instrumentation Neutron Activation Method Theory, instrumentation, destructive and nondestructive method, Applications. Isotopic Dilution Method: Principal, methods and Applications	**15 HRS**
Unit 3	**Polarography** Polarography: Principles, classification of polarographic techniques, types of polarographic currents, instrumentation, factors affecting polarographic wave, pulse polarography, and differential pulse polarograph,square wave polarography.Applications	**15 HRS**
Unit 4	**Voltammetry:** Voltammetric principles, hydrodynamic voltammetry, stripping voltammetry Cyclic voltammetry: Cyclic wave form,criteria for reversibility of electrochemical reactions, quasi-reversible and irreversible processesQualitative and Quantitative analysis	**15 HRS**
Unit 5	**Sensors** Ion Selective Electrode: Classification,Application **Sensors:**Definition-Classification-Optical,Thermal,Electrochemical,Condution sensors, Gas sensors**Biosensors:**Introduction, Working of Glucose Biosensors	**15 HRS**

Suggested Readings:

1. Modern Polarographic Methods in Analytical Chemistry, AM Bond, Marcel Dekker.
2. Electrochemical Methods: Fundamentals and Applications, AJ Bard and LR Faulkner.
3. Principles of Instrumental Analysis, DA Skoog and JL Loary, WB Saunders.
4. Handbook of Instrumental Technique for Analytical Chemistry, F.Settle, Prentice Hall.
5. Laboratory Technique in Electronanalytical Chemistry, PT Kissinger and HR Heinaman, Marcel decker.
6. Analytical Chemistry, GD Christian, J Wiley.
7. Chemical Sensors, RW Cattrall, Oxford University Press.
8. Principles of Instrumental Analysis, DA Skoog, DM West and FJ Holler, WB Saunders

MSCH221: LABORATORY COURSE V: ORGANIC CHEMISTRY	
	Qualitative Analysis Separation, purification and identification of compounds in given binary mixture (one liquid and one solid and solid- solid mixture) separation using chemical methods as well. **Quantitative Analysis** a. Determination of the percentage or number of hydroxyl group in an organic compound by acetylation method& periodate method. b. Estimation of amines/phenols acetylation method. c. Determination of Iodine and Saponification values of an oil sample. d. Estimation of glucose by colorimeter. e. Estimation of formaldehyde by iodometry. **Organic Preparation** a. Aromatic electrophilic substitution: p-nitroacytanilide & p-bromoacetanilide b. Cannizaro-reaction: benzaldehyde

Suggested Readings:

1. Practical Organic Chemistry, SP Bhutani & Aruna Chhikara, Ane Books India
2. Elementary Practical Organic Chemistry Part I & II, Arthur I Vogel, CBS
3. Advanced Practical Organic Chemistry, NK Vishnoi, Vikash Publication

MSCH222: LABORATORY COURSE IV: ANALYTICAL CHEMISTRY	
	I. Spectrophotometer 1. To determine the concentration of two components in the mixture of $K_2Cr_2O_7$& $KMnO_4$/ $CoCl_2$& $NiSO_4$ 2. To determine the pKa of indicator (Methyle Red) in aqueous medium. **II. Fluorometry:** To determine the concentration of quinine sulphate, Vitamin B (Riboflavin) and Aluminium. **III. Nephelometry:** To determine the concentration of sulphate content in water sample. **IV. Flame photometry** 1. Estimation of Na^+ and K^+. 2. Estimation in a mixture (Na^+ and K^+). 3. To determine the Na and K content in the given soil sample. **V. Water and Waste Water examination** 1. To determine the concentration of Fluoride, nitrite and phosphate spectrophotometrically. 2. Determination of dissolve oxygen in water sample 3. Determination of chemical oxygen demand (COD) in water sample. **VI. Atomic Absorption Spectroscopy:** To determine the trace metal (Pb, Cu, Zn) in soil sample using AAS

Suggested Readings:

1. Handbook of Instrumental Technique for Analytical Chemistry, F. Settle, Prentice Hall.
2. Vogel's Text book of Quantitative Inorganic Analysis, Basset RC, Denny GH, Jeffery and Mandan J, ELBS.

MSCHSC231: FUNDAMENTAL CONCEPT OF CHEMICAL CALCULATIONS: STOICHIOMETRY

(For students of other departments)

THEORY:

Atomic weight, molecular weight, empirical formulae and its determination ,the mole concept:elementry problem ,problem based on equation: stoichiometry , equivalent weight and chemical equivalence, concentration units and volumetric calculation.

Practical:

Numerical problem based on above concept.
Preparation of solution: primary and secondary standard.
Dilution of solutions.

Suggested Books:

(1) Modern approach to chemical calculation by R.C.Mukherjee,Bharti Bhavan P&D
(2)Stoichiometry by B.I.Bhatt and S.B.Thakore.
(3) Stoichiometry and process calculations: K.V.Narayanan and B.Laxmikutty

TEACHING AND EXAMINATION SCHEME
THIRD SEMESTERCORE COURSE:

2018-19

CODE	DESCRIPTION	PD/W	PD/SEM	EXAM	CIA	ESE	TOTAL
MSCH311	ORGANIC SPECTROSCOPY	4	60	3 HRS	30	70	100
MSCH312	SOLID STATE, SURFACE CHEMISTRY & CATALYSIS	4	60	3 HRS	30	70	100
MSCH313	ORGANOTRANSITION METAL CHEMISTRY	4	60	3 HRS	30	70	100
ELECTIVE							
MSCH314(A)	ORGANIC SYNTHESIS-I	4	60	3 HRS	30	70	100
OR							
MSCH314(B)	MATERIAL CHEMISTRY	4	60	3 HRS	30	70	100
TOTAL THEORY							400
MSCH322	LABORATORY COURSE V: INVESTIGATORY PROJECT	**9**	**135**	12 HRS	30	70	100
MSCH323	LABORATORY COURSE IX: ORGANIC CHEMISTRY	**6**	**90**	6 HRS	15	35	50
GRAND TOTAL							**550**

Note:

1. A board of two examiners (**one internal and one externa**l) will be appointed for conducting the examination of each laboratory course.
2. In practical exam one major and minor experiment will be allotted in each lab course.
3. In inorganic mixture student can consult book for basic radicals after reporting the concern groups.
4. In organic mixture student can consult book for confirmatory test of the compounds after reporting the initial physical properties, element detection, functional group & melting/boiling point of the compound.
5. Practical Exam shall be conducted in two days where ever required (Hours).

SKILL BASED COURSE IN CHEMISTRY FOR CHEMISTRY STUDENTS:

STUDENT HAVE TO OPT ONE SKILL BASED PAPER FROM EITHER PAPERS: MSCHSC331(A) or (B).

CODE	DESCRIPTION	THEORY		PRACTICALS	
		HRS/W	HRS/SEM	HRS/W	HRS/SEM
MSCHSC331(A)	COSMETICOLOGY AND COSMETIC PREPARATION-II	2	30	2	30
MSCHSC331(B)	TESTING OF ADULTRATION IN MILK & MILK PRODUCTS	2	30	2	30

MSCH311: ORGANIC SPECTROSCOPY		
Unit 1	**Ultraviolet and Visible Spectroscopy** Various electronic transitions (185-800 nm), Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes Woodward- Fieser rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic, heterocyclic compounds and steric effect in biphenyl.	**15 HRS**
Unit 2	**Mass Spectrometry** Introduction, ion production EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Molecular ion peak, metastable peak, Mc Lafferty rearrangement and Nitrogen rule. High resolution mass spectrometery .Mass spectral fragmentation of organic compounds containing common functional groups.	**15 HRS**
Unit 3	**Infrared Spectroscopy** Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds).Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance.FTIR.IR of gaseous, solids and polymeric materials. **Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD):** Definition, deduction of absolute configuration, axial halo- ketone and octant rule for ketones.	**15 HRS**
Unit 4	**Nuclear Magnetic Resonance Spectroscopy** General introduction and definition, chemical shift, spin- spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides &mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contact shift reagents, solvent effects.	**15 HRS**
Unit 5	**Carbon-13 NMR Spectroscopy** General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, hetero-aromatic and carbonyl carbon), coupling constants Fourier transform technique, nuclear Overhauser effect (NOE). **Two-dimension NMR spectroscopy** COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques. Problems of the structure elucidation using above mentioned spectroscopic techniques.	**15 HRS**

Suggested Readings:

1. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
2. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
3. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
4. Application of Spectroscopy of Organic Compounds, J.R. D yer, Prentice Hall.
5. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.

MSCH312: SOLID STATE, SURFACE CHEMISTRY & CATALYSIS		
Unit 1	**Solid state chemistry-I** General principles, experimental procedures. Crystal Defects, Perfect and imperfect crystals, intrinsic and extrinsic defects point defects, line and plane defects. Thermodynamics of Schottky and Frenkel defect formation, colour centers.	**15 HRS**
Unit 2	**Solid State Chemistry-II** Electronic Properties and Band Theory Metals, insulators and semiconductors, band theory of solids (qualitative treatments), band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, p-n junctions. Superconductors factors affecting the super conductivity, magnetic properties, persistent current and BCS theory of superconductors. Optical properties, photoconduction. Magnetic Properties, Classification of materials, Magnetic domains, hysteresius.Organic Solids. Electrically conducting solids, organic charge transfer complex- new superconductors	**15 HRS**
Unit 3	**Surface Chemistry-I** General structural features and behaviour of Surfactants: general use of charge types, effect of hydrophobic group, anionic, cationic, nonionic and zwitter ionic surfactants **Adsorption:** Estimation of surface area (BET equation), surface films on liquids, **Micelles:** Surface active agents, Classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentrations (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles,psuedophase model of micelles catalysis (proximity effect).	**15 HRS**
Unit 4	**Surface Chemistry-II** **Solubilization of surfactants:** Solubilization in aqueous media; locus of solubilization, factors determining the extent of solubilization, effects of solubilization **Detergency and surfactants:** Mechanism of cleaning process, removal of soil from substrate, suspension of soil in bath and prevention of redeposition, dry cleaning, skin irritation, effect of water hardness and chemical structure of surfactants and its detergency.	**15 HRS**
Unit 5	**Phase Transfer catalysis& ultrasound:** Definition and importance of phase transfer catalysis, quaternary ammonium and phosphonium salts, crown eathers and other crypatants. Use of ultrasound.	**15 HRS**

Suggested Readings:

1. Solid state chemistry and its applications, West A.R., Plenum.
2. Principles of solid state, Keer H.V., Wiley Eastern
3. Solid state chemistry, Chakrabarty D.K., New Wiley Eastern
4. Solid state chemistry: An introduction, Moore E., and Smart L., Chapman Hall, 1996
5. Crystallography made crystal clear: A guide for users of macromolecular models, Rhodes G., Elsevier, 2006.
6. X-ray diffraction, Warren B., Dover Publications
7. Introduction to crystallography, Sands, D.E., Dover Publications.
8. Principles and practice of heterogenous catalysis, Thomas J.M. and Thomas M.J., John Wiley
9. Concepts of modern catalysis and kinetics, Chorkendoff I.B. and Niemantsverdriet J.M.
10. Physical chemistry of surfaces, Adamson A.W., Wiley Interscience, 1997
11. Surfactants and interfacial phenomenon, Milton J. Rosen, wileyinterscience.

MSCH313: ORGANOTRANSITION METAL CHEMISTRY		
Unit 1	**Organotransition Metal Complex** Definition, Classification and nomenclature Types of ligendsamd M-L bonding: - lone pair donor, pi bonding electron pair donor, Hapticity, ambidentate ligands, 18 Electron rule: electron counting, ionic v/s covalent model, compliance and violation of the rule oxidation state of the metal.	**15 HRS**
Unit 2	**Basic reaction in organometallic chemistry** Oxidative addition, reductive elimination, insertion elimination, ligand substitution nucleophilic and electrophilic addition and abstraction Fluxional organometallic compound: Rate of rearrangement and study technique, fluxional molecules of C. No. 4, 5, 6	**15 HRS**
Unit 3	**Complex of sigma-bonded ligands** Preparation, structure bonding and reaction of alkyl and aryl transition metal **Complexes of pi-bonded ligands: -** Preparation, structure and reaction of alkenes cyclopentadienyl complexes, arenas, carbonyl complexes	**15 HRS**
Unit 4	**Metal cluster and metal-metal bond** Structures, Isolable analogy, synthesis **Catalysis**: Basic terminology turn over, turnover number, turn over frequency, Dehydrogenation of alkene, Hydroformylation, Monsanto process, Wacker process, Alkene isomerization, Olefin metathesis	**15 HRS**
Unit 5	Applications of organometallic chemistry in organic synthesis Heck reaction, Suzuki – miyaura reaction, Sonagashira reaction, Stille coupling, Kumada coupling, Pauson – khand reaction, Ullmann reaction, Organo copper compounds Application in medicine, agriculture, industries	**15 HRS**

Suggested Readings

1. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John, Wiley.
3. Metallo-organic Chemistry, A.J. Pearson, Wiley.
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.

MSCH314(A): ORGANIC SYNTHESIS-I		
Unit 1	**Organometallic Reagents** Principle, preparations, properties and applications of the following in organicsynthesis with mechanistic details. **Group I and II metal organic compounds** Li, Mg, Hg, Cd, Zn and Ce compounds. **Transition metals** Cu, Pd, Ni, Fe, Co, Rh, Cr and Ti compounds. **Other elements** S, Si and B compounds.	**15 HRS**
Unit 2	**Oxidation** Introduction, Different oxidative processes. Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated andunactivated).Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids.Amines, hydrazines, and sulphides. Oxidations with ruthenium tetraoxide, iodobenzene diacetate and thallium (III) nitrate.	**15 HRS**
Unit 3	**Reduction** Introduction. Different reductive processes. Hydrocarbons – alkanes, alkenes, alkynes and aromatic rings. Carbonyl compounds – aldehydes, ketones, acids and their derivatives Epoxides.Nitro, nitroso, azo and oxime groups. Hydrogenolysis.	**15 HRS**
Unit 4	**Rearrangements** General mechanistic considerations – nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii,Arndt-Eistert synthesis, Neber, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction.	**15 HRS**
Unit 5	**Polycyclic Aromatic Compounds.** Napthelene,Phenanthrene, Anthracene: Introduction and aromaticity, general methods for synthesis,reactions and spectroscopic properities Synthesis of linear ortho-fused and Non- linear ortho fused polynuclear hydrocarbons: Napthacene,Benz[a] anthracene, Dibenz[a,j] anthracene,Chrysene, Picene Synthesis of ortho and peri fused polynuclear hydrocarbons: Pyrene,Corolene 20-methylcholanthrene and circumanthracene.	**15 HRS**

Books Suggested:

1. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
2. Somer Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March, John Wiley.
4. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
5. Advanced Organic Chemistry Part B. F.A. Carey and R.J. Sundberg, PlenumPress.
6. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.

MSCH314(B): MATERIAL CHEMISTRY		
Unit 1	**Multiphase Material :** Classification and properties of materials, Types of phase diagrams, Isomorphous, Eutectic, Peritectic, Monotectic and Eutectoid systems, Calculation of phase amounts from a phase diagram, Phase rule, Ferrous alloys Fe-C phase diagram, Non Ferro alloys, Phase diagrams of brass and tin bronze.	**15 HRS**
Unit 2	**Composite Materials:** Definition: composite, matrix materials: polymer, metal, ceramic and glass matrix. Reinforcement: dispersion reinforcement, partical reforcement, laminated reinforcement and fiber reinforcement. Natural and traditional composites (concrete, asphalt, wood)	**15 HRS**
Unit 3	**Polymeric and advanced materials:**Brief idea of following: Insulating material, Semiconductors, Superconductors, Fullerenes, Optical fibers, Organic electronic material. **Optical fibers:** Refraction, reflection, absorption and Transmission. Application of Optical phenomena.	**15 HRS**
Unit 4	**Corrosion and Degradation of materials:**Introduction, Corrosion of metal: Electrochemical consideration,Corrosion rates, Passivity, Corrosion environment. **Corrosion prevention:** Corrosion of ceramic materials, Degradation of polymer: swelling and dissolution, Bond Rupture, Weathering.	**15 HRS**
Unit 5	**Surface science of Material :** **Surface of metal:** Etching of metal surfaces, Metal surface and Vapor deposition, Sputtering, Solution reaction. **Ceramic surfaces:** Oxide ceramic surface, Nonoxide ceramic fiber surface. **Polymer Surface:** General Aspect of Polymer Surface, Chemical Modification of Polymer Surface, Plasma Modification of polymer surface.	**15 HRS**

Suggested Readings:

1. Solid State Physics, NW Ashcroft and ND Mermin, Saunders College.
2. Handbook of Liquid Crystals, Kelker and Hatz, ChemieVerlag
3. Nanostructures materials: Processing, Properties and applications, C. C. Kouch, William Andrew publications, New York, 2002.

4. Fundamentals of Materials science and Engineering. William D. Callister, Jr, Jhon Wiley and Sons, Inc.
5. Introduction to Material Chemistry, Harry R. Allcock, Wiley and Sons, Inc.

MSCH321: INVESTIGATORY PROJECT

Student had to carry out an investigatory project under the guidance of the alloted guide and submit the dissertation of the same at end of the semester.

Viva voce examination and presentation of the project will be held during the practical examination.

Marking Scheme for the Project:

CCA **:** 30 Marks (Including 10 marks of the attendance)

Project Report (Dissertation): 35 Marks

Presentation **:** 15 Marks

Viva Voce **:** 20 Marks

MSCH322: LABORATORY COURSE VI: ORGANIC CHEMISTRY	
	I. **Separation, purification and identification** of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid). **II.** **Extraction of Organic Compounds from Natural Sources** (purity of isolated compound may be checked by chemical test TLC or Paper chromatography): a. Isolation of cafeine from tea leaves. b. Isolation of casein from milk. c. Isolation of lactose from milk. d. Isolation of lycopene from tomatoes. **III.** Interpretation of IR NMR and Mass Spectra of Organic Compounds.

Suggested Readings:

1. Systematic Qualitative Organic analysis by H. Middleton.
2. Qualitative and Quantitative hand book of Organic analysis by H. Clark
3. Vogel's Text book of practical Organic Chemistry by Vogel
4. Practical Organic Chemistry by N.K. Vishnoi

MSCHSC331 (A): COSMETICOLOGY AND COSMETIC PREPARATION-II

THEORY:

Fundamentals of cosmetic science. Classification of cosmetics. Structure and function of skin and hair. Formulation, preparation and packaging of cosmetics gargle, mouthwash, throat paint, mouth freshener, Astringent lotion.

PRACTICAL:

1. To prepare mouthwash.
2. To prepare and dispense effervescent granules.
3. To prepare and dispense potassium chlorate gargle.
4. To prepare and dispense saline mouthwash.
5. To prepare and dispense throat paint.
6. To prepare and dispense mentho-eucalyptus mouth freshener
7. To prepare and dispense Hydrogen peroxide mouth wash (6 % w/w).
8. To prepare and submit Astringent lotion.

Suggested Reading:

1. Ansel H. C, Introduction to Pharmaceutical Dosage Forms, K M Varghese and, Bombay.
2. Jellinek J. S., Formulation and Function of Cosmetics, John Wiley and sons, NY.
3. B.M. Mithal, A Handbook of Cosmetics, Vallabh Praakashan Delhi
4. P. P. Sharma, " Cosmetics- formulation, Manufacturing and Quality control" , Vandana Publication, Delhi
5. Indian Pharmacopoeia, I.P., Edition II, Year 1966,
6. Cooper and Guns "Dispensing for Pharmaceutical Students", CBS Publisher, New Delhi

MSCHSC331 (B): TESTING OF ADULTRANTS IN MILK AND MILK PRODUCTS

THEORY:

Introduction, types of milk, general composition of milk, physical and microscopic properties of milk (fat globules, cellular element, refraction, gravity, conductivity, capillary phenomenon and curd tension)

Milk products- pasteurized milk, artificial milk condensed milk, milk powder, cream butter, ghee, cheese.

Artificial coloring, flavors, rancidity in milk products

PRACTICAL:

Detection of adulterants in milk

1. Qualitative determination of starch in milk products (Paneer, Mava etc.).
2. Detection of neutralizers in milk (carbonate & bi carbonate).
3. Test of urea and detergents in milk and milk products.
4. Test of dextrin in milk.
5. Test of nitrate and fluoride in milk and milk products.
6. Test of formalin in milk and milk products.

SUGGESTED READINGS:

1. Manual of methodsof analysis of foods by FSSAI.
2. Milk and milk products by Winton & Winton

TEACHING AND EXAMINATION SCHEME
FOURTH SEMESTER CORE COURSE:

2018-19

CODE	DESCRIPTION	PD/W	PD/SEM	EXAM	CIA	ESE	TOTAL
MSCH411	BIOINORGANIC AND SUPRAMOLECULAR CHEMISTRY	4	60	3 HRS	30	70	100
MSCH412	HETEROCYCLIC CHEMISTRY	4	60	3 HRS	30	70	100
MSCH413	PRINCIPLES & APPLICATIONS OF SPECTROSCOPY	4	60	3 HRS	30	70	100
ELECTIVE							
MSCH414(A)	ORGANIC SYNTHESIS-II	4	60	3 HRS	30	70	100
OR							
MSCH414(B)	NANOSCIENCE	4	60	3 HRS	30	70	100
TOTAL THEORY							400
MSCH421	LABORATORY COURSE VII: PHYSICAL CHEMIETRY	**9**	**135**	12 HRS	30	70	100
MSCH422	LABORATORY COURSE VIII: INORGANIC CHEMISTRY	**6**	**90**	6 HRS	15	35	50
GRAND TOTAL							**550**

Note:

1. A board of two examiners (**one internal and one externa**l) will be appointed for conducting the examination of each laboratory course.
2. In practical exam one major and minor experiment will be allotted in each lab course.
3. In inorganic mixture student can consult book for basic radicals after reporting the concern groups.
4. In organic mixture student can consult book for confirmatory test of the compounds after reporting the initial physical properties, element detection, functional group & melting/boiling point of the compound.
5. Practical Exam shall be conducted in two days where ever required (Hours).

SKILL BASED COURSE IN CHEMISTRY FOR OTHER STUDENTS:

CODE	DESCRIPTION	THEORY		PRACTICALS	
		HRS/W	HRS/SEM	HRS/W	HRS/SEM
MSCHSC431	BASIC SKILLS IN SPECTROSCOPIC ANALYSIS	2	15	2	30

SKILL BASED COURSE OFFERED BY OTHER DEPARTMENTS FOR CHEMISTRY STUDENTS:

STUDENT HAVE TO OPT ANY ONE OF SKILL BASED PAPER FROM SKILL BASED PAPERS OFFERED BY OTHER DEPARTMENTS.

MSCH411: BIOINORGANIC AND SUPRAMOLECULAR CHEMISTRY		
Unit 1	**Metal storage Transport and Bio-mineralization** Oxygen carrier (Hb& Mb), ferritin, transferrin and siderophores. **Calcium in Biology:** Calcium in living cells, transport and regulation, molecular aspects of intramolecular process, extracellular binding protein, Ca^{+2}ATPase, Ca^{+2} ATPase structure, Ca^{+2}ATPase reaction cycle, intracellular Ca^{+2} transport.	**15 HRS**
Unit 2	**Metalloenzyme** **Zinc enzymes:** Carboxy peptidase and carbonic anhydrase. **Iron enzymes:** Reactivity and structure of catalase, peroxidase and cytochrome P450, copper enzymes their Reactivity and structure of superoxide dismutase (SOD). Co enzyme vitamin B-12: structure,function,absorption, transport and metabolic.	**15 HRS**
Unit 3	**Metal nucleic acid interaction:** Fundamental interaction with nucleic acid, fundamental reactions with nucleic acid TRIS(Phenanthroline) metal complexes: Binding with DNA, Applications of different metal complexes that bind nucleic acid **Metal in medicine:** Metal deficiency and disease, toxic effect of metals (Lead, mercury, cadmium, chromium, aluminum, iron, arsenic, copper, zinc, cobalt), metal used for diagnosis and chemotherapy with particular reference to anticancer drugs.	**15 HRS**
Unit 4	**Supramolecular chemistry I** Introduction, concepts and language molecularreorganization: molecular receptors for different types of molecules including anionic substrates, design and synthesis of receptor molecules and multiple recognition.	**15 HRS**
Unit 5	**Supramoleculer chemistry II** Supramolecular reactivity and catalysis, supramolecular assemblies, supramolecular devices, supramolecular photochemistry, molecular and supra molecular photonic devices, supramolecular electronic, ionic and switching devices	**15 HRS**

Suggested Readings:

1. Principles of Bioinorganic chemistry, S.J. Lippard and J.M. Berg, University science books.
2. Bioinorganic chemistry, I Bertini, H.B. Garg, S.J. Lippard and J.S. Valentine, University science books.
3. Inorganic Biochemistry, Vol I and II Ed. G.S. Eichhorn, Elsevier
4. Progress in Inorganic Chemistry Vol. 18 and 38 ed., J.J. Lippard, Wiley.
5. Supra molecular chemistry, J.M. Lehn, VCH.
6. Bioinorganic chemistry, A.K. Das, Books and allied (P) Ltd.
7. Bioinorganic and supra molecular chemistry, Ajay Kumar Bhagi, G.R. Chatwal, Himalaya publishing house

MSCH412: HETEROCYCLIC CHEMISTRY		
Unit 1	**Nomenclature of heterocycles:** Systemic nomenclature of monocyclic, fused & bridge heterocycles. **Three Membered Heterocyclic Compounds with One Hetero Atom:**Aziridines, Oxiranes and Thiiranes **Three Membered Heterocyclic Compounds with Two Hetero Atoms:**Diaziridines, Diazirines and Oxaziridines	**15 HRS**
Unit 2	**Four Membered Heterocyclic Compounds with One Hetero Atom:** Azitines&Azitidines, Oxitanes, Thietanes and Carbonyl Derivatives: 2-Azitidinones and Oxetanone. **Five Membered Heterocyclic Compounds with One Hetero Atom:**Tautomerism , Pyrroles, Furans and Thiophenes	**15 HRS**
Unit 3	**Five Membered Heterocyclic Compounds with Two Hetero Atoms**: Pyrazoles, Imidazoles, Oxazoles and Thiazoles. **Bicyclic Ring Systems Derived from Pyrrole, Furan and Thiophene:** Benzopyrroles, benzofurans and benzothiophenes.	**15 HRS**
Unit 4	**Six Membered Heterocyclic Compounds with One Hetero Atom:** Pyridines, Pyrylium salts and Pyrones **Six Membered Heterocyclic Compounds with Two Hetero Atoms:**Pyrazines, Pyridazines and Pyrimidines,Quinazolines and Quinoxalines	**15 HRS**
Unit 5	**Seven Membered Heterocyclic Compounds with Two Hetero Atoms:** Azepines, Oxepins and Thiepins **Bicyclic Ring Systems Derived from Pyridine:** Quinoline and Isoquinoline, Acridines and Phenanthridines	**15 HRS**

Suggested Readings:

1. Heterocyclic Chemistry Vol. 1-3, RR Gupta, M Kumar and V Gupta, Springer Verlag.
2. The Chemistry of Hetrocycles, T Eicher and S Hauptmann, Thieme.
3. Heterocyclic Chemistry, JA Joule, K Mills and GF Smith, Chapman and Hall.
4. Heterocyclic Chemistry, TLGilchrist, Longman Scientific Techinal.
5. Contemporary Heterocyclic Chemistry, GR Newkome and WW Paudler, Wiley-Inter Science.
6. An Introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley.
7. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon Press.

MSCH413-PRINCIPLES AND APPLICATIONS OF SPECTROSCOPY		
Unit 1	**Fundamental of Spectroscopy** Electromagnetic radiation, Born-Oppenheimer approximation, types of spectra, intensity of spectral lines, transition probability, transition moment, natural line width and natural line broadening and selection rules. **Microwave Spectroscopy:**Classification of molecules, rigid and non-rigid rotator model, effect of isotopic substitution on the transition frequencies and intensities, stark effect, nuclear and electron spin interaction and effect of external field and applications.	**15 HRS**
Unit 2	**Infrared Spectroscopy** Review of harmonic oscillator, vibrational energies of diatomic molecules, zero-point energy, force constant and bond strengths, normal modes of vibration, anharmonicity, overtones, hot bands, selection rules, group frequencies, Hook's law and calculation of frequencies for different types of bonds, factors affecting bond position and intensities and applications. **Raman spectroscopy:**Classical and quantum theories of Raman Effect, pure rotational, vibrational and vibrational rotational Raman spectra, selection rules, mutual exclusion principle and applications.	**15 HRS**
Unit 3	**Vibrational Spectroscopy of Polyatomic molecules** Symmetry of normal modes of molecules, infra-red and Raman activity of: Bent AB_2 type molecules and comparision with other C_{2v} molecule like ZAB_2, ClF_3, cis-N_2F_2, cis-$PtCl_2L_2$, CH_2Cl_2, cis-ML_2X_4 and mer-ML_3X_3. AB_4 type molecules having tetrahedral, square planar, square pyramidal and see saw shape & octahedral molecules. **Electronic Spectroscopy:** Intensity of vibrational – electronic spectra: frank codon principle, rotational fine structure of electronic-vibration transitions, concept of potential energy curve for bonding and antibonding orbital. Qualitative description of selection of σ, π and non-bonding molecular orbital their energy level and respective transitions, selection rules for electronic spectroscopy and chemical analysis by electronic spectroscopy.	**15 HRS**
Unit 4	**Electron Spin Resonance Spectroscopy (ESR)** Basic Principle, ESR Instrumentation, hyperfine splitting, factors affecting the 'g' Value, Zero Field Splitting, Isotropic and Anisotropic Hyperfine Coupling Constants, Spin Hamiltonian, Spin Densities and applications. **Nuclear Quadrupole Resonance Spectroscopy (NQR)** Basic principle, effect of magnetic field on spectra, electric field gradient and molecular structure and applications.	**15 HRS**
Unit 5	**Mossbauer Spectroscopy** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structure of Fe^{2+} and Fe^{3+} compounds including those of intermediate spin (2) Sn^{2+} and Sn^{4+} compounds, nature of metal ligand bonding, coordination number, structure and (3) detecction of oxidation state and inequivalet MB atoms. **Photoelectron Spectroscopy:** Photo-electric Effect, Ionization Process and Koopman's Theorem. UV Photoelectron Spectra of atoms and Simple Molecules, X-ray photoelectron spectra of gases and solids. **Auger electron spectroscopy:** Auger electron ejection and its examples.	**15 HRS**

Suggested Readings:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience.

3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill Basic
6. Principles of Spectroscopy. R. Chang, McGraw Hill
7. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
8. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley
9. Introduction to Magnetic Resonance, A. Carrington and A.D. Maclachalan, Harper & Row.

MSCH 414 (A): ORGANIC SYNTHESIS-II		
Unit 1	**Disconnection Approach** An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemo selectivity, reversal of polarity, cyclisation reactions, amine synthesis.	**15 HRS**
Unit 2	**Protecting Groups** Principle of protection of alcohol, amine, carbonyl and carboxyl groups. **Ring Synthesis** Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis.	**15 HRS**
Unit 3	**One Group C-C Disconnections** Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.	**15 HRS**
Unit 4	**Two Group C-C Disconnections** Diels-Alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Micheal addition and Robinson annelation.	**15 HRS**
Unit 5	**GREEN SYNTHESIS:** Introduction, basic principles of green chemistry and their illustrations with examples. Green synthesis of adipic acid, catechol, 3- dehydroshikimic acid acetaldehyde, ibuprofen and paracetamol,methyl methacrylate,urethane and marine ani foulant.	**15 HRS**

Books Suggested:

1. Designing Organic Synthesis, S. Warren, Wiley.
2. Organic Synthesis- Concept, Methods and Starting Materials, J. Fuhrhop and G.
3. Penzillin, Verlage VCH.
4. Some Modern Methods of Organic Synthesis. W. Carruthers, Cambridge Univ.
5. Press.
6. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
7. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, J. March,
8. Wiley.
9. Principles of Organic Synthesis, R. Norman and J.M. Coxon, Blackie Academic
10. New Trends in Green Chemistry V.K. Ahluwalia, M. Kidwai, Anamaya Publishers
11. Modern Synthetic Reaction, H.O. House, W.A. Benjamin.
12. Some Modern Methods of Organic Synthesis, W.Carruthers, Cambridge university Press
13. Advanced Organic Chemistry, Reaction Mechanisms and Structure, J. March, John Wiley.
14. Organic Synthesis – the Disconnection approach, S.Warren ,Wiley
15. Advanced Organic Chemistry, Part B, F. A. Carey and R.J. Sundberg, Plenum Press

MSCH414 (B) - NANOSCIENCE		
Unit 1	Introduction: Nano scale concept, Nanoparticle and Nanomaterial, classification Effect of nanometer length scale: Quantum confinement and surface to volume ratio. Unique properties of Nanomaterial Physical properties: electrical,magnetic,thermal,optical properties and Chemical properties:Catalyst,M.P,B.P.	**15 HRS**
Unit 2	Nano synthesis: Concept of Top down and Bottom up Technique,Chemical method:Chemical vapor deposition(CVD),Reduction method,Sol-Gel method,sonochemical method. Physical method:lithography,Sputtering,Aerosol spraying	**15 HRS**
Unit 3	Nanostructure material:General structure, Preparation and Properties of nanomaterial: Carbon Nano tubes(CNT), Graphene and Fullerene, Inorganic metal Nanoparticle of silver and gold, Metal oxide nanoparticles,Polymeric Nanomaterial.	**15 HRS**
Unit 4	Characterization Technique: General classification of characterization technique, Electron Microscopy: Scanning electron microscopy(SEM), Transmission electron microscopy(TEM) Scanning Probe Microscope Technique; Atomic force Microscopy(AFM) Safety and Storage of nanoparticles Particle size Analyzer; DLS (Dynamic light scattering), X-ray Diffraction(XRD)	**15 HRS**
Unit 5	Applications of Nanotechnology in field of Energy: Pharmaceuticals, Clinical and Healthcare, Security and Environment	**15 HRS**

Suggested Readings:

1. Willard "Instrumental Methods of Analysis" 2000
2. Charles P.Poole,Jr and Frank J Owens ;Introduction to Nanotechnology, Wiley ,2003
3. Nanostructures materials: Processing, Properties and applications, C. C. Kouch, William Andrew publications, NewYork, 2002.
4. Introduction to nanotechnology, C. P. Poole Jr, F. J. Owens, 2nd edition, Wiley-India, Delhi, 2008.
5. Nanostructures and nanomaterials, G. Cao, Imperial College Press, University of Washington, USA, 2004
6. Nanotechnology Fundamentals and applications, M. Karkare, I. K. Interna
7. Essentials in nanoscience and nanotechnology,N.Kumar and S.Kumbhat,John Wiley(NY),2016
8. Nanoscale and Technology,Robert Kesall,John Wiley.
9. Nanochemistry, Nishit mathur,RBSA Publisher,2010
10. Harry R lock.Introduction to Material Chemistry,Wiley

MSCH421: LABORATORY COURSE VII: PHYSICAL CHEMISTRY

A. Chemical Kinetics

a. To investigate the kineticsof the reaction between I- and persulphate ion
   i. Order of the reaction
   ii. Energy of activation of the reaction.
   iii. Effect of ionic strength on rate.
b. To find out the order of the reaction of saponification of ester using unequal concentrations of reactants.
c. To study the reaction between ceric ammonium nitrate and primary alcohol.

B. Conductometry:

a. To find out the equivalent conductance of strong electrolytes at different dilutions and to verify Debye HuckelOnsagar equation.
b. To determine the equivalent conductance of a weak electrolyte at infinite dilution. To determine the dissociation constant of acetic acid/Oxalic acid and verify the Ostwald's dilution law.
c. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by NaOHconductometrically.

C. Phase Equilibrium:

a. To find out the equilibrium constant for the triiodide formation.
b. To find the formula of complex cuprmmonium ion by distribution method.
c. To contracture the phase diagram for three component system (e.g. Chloroform acetic acid-water)

D. Polarimetry

a. To determine the specific rotation of a given optically active compound.

Suggested Readings:

1. Practical Physical Chemistry, A.M. James and F. E. Prichard, Longman.
2. Findley's Practical Physical Chemistry, B.P. Levitt, Longman. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.
3. Advanced Practical Physical Chemistry, J.B. Yadav, Goel Publishing House.
4. Advanced Experimental Chemistry, vol.1, Physical J.N. Gurtu and R. Kapoor, S. Chand & Co.

MSCH422: LABORATORY COURSE VIII: INORGANIC CHEMISTRY

I. Preparations

a. $Na_3[Fe(C_2O_4)_3]$
b. Prussian Blue($Fe_4[Fe(CN)_6]$)
c. $[Ni(NH_3)_6]\ Cl_2$
d. $[Ni(dmg)_2]$
e. Potassium Chlorochromate
f. $Na_3[Co(NO_2)_6]$
g. $K_3[Cr(C_2O_4)_3].3H_2O$
h. Cis& trans potassium diaquodioxalatochromate(III)
i. Potassium trioxalatochromate(III).
j. Cuprous tetraiodomercurate(II).
k. Tetraamminecarbonatocobalt(III) nitrate.
l. Pentaamminechloridocobalt(III) chloride.

	m. Tris(acetylacetonato)manganese(III) ion **II.** Determination of stability constant and composition of complex by Job's method. (Iron Thiocyanide & Iron phenanthroline). **III.** Analysis of some alloys.

MSCHSC431 (A): BASIC SKILL IN SPECTROSCOPIC ANALYSIS

THEORY:

Electromagnetic radiations and their principle,basics of spetroscopic,absorption and emission , flame photometry: Basic principal instrumentation and application.

Atomic Absopation spectrocsopy: Basic principle, instrumentation ,types of burners,hollow cathod lamps, detection and application.

PRACTICALS:

1. Estimation of Na,K,Ca and Li in water and soil sample.
2. Determination of Zn,Cu and Fe etc.in water and soil sample.
3. Determination of common heavy metal ion in biological sample.

Suggested Readings:

1. Vogel's Textbook of Quantitative Chemical Analysis, G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney, Publ ELBS, Longman, UK
2. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.
3. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler. Pubi WB Saunders.
4. Analytical Chemistry, G.D. Christian, John Willy & Sons.