MASTER OF SCIENCE POLYMER CHEMISTRY

1st Semester

PAPERS CODE	PAPERS NAME	INTERNAL	EXTERNAL	TOTAL
MSCPC101	ORGANOMETALLICS AND NUCLEAR CHEMISTRY	40	60	100
MSCPC102	STRUCTURAL AND MOLECULAR ORGANIC CHEMISTRY	40	60	100
MSCPC103	QUANTUM CHEMISTRY AND GROUP THEORY	40	60	100
MSCPC104	THERMODYNAMICS, KINETIC THEORY AND STATISTICAL THERMODYNAMICS	40	60	100
MSCPC105	MORPHOLOGY AND PHYSICAL CHEMISTRY OF POLYMERS	40	60	100
Practical				
MSCPC106	LABORATORY I	60	40	100
MSCPC107	LABORATORY II	60	40	100
Total		**320**	**380**	**700**

2nd Semester

PAPERS CODE	PAPERS NAME	INTERNAL	EXTERNAL	TOTAL
MSCPC101	COORDINATION CHEMISTRY	40	60	100
MSCPC102	ORGANIC REACTION MECHANISMS	40	60	100
MSCPC103	CHEMICAL BONDING AND COMPUTATIONAL CHEMISTRY	40	60	100
MSCPC104	STEP-GROWTH POLYMERS	40	60	100
MSCPC105	COORDINATION CHEMISTRY	40	60	100
Practical				
MSCPC104	LABORATORY I	60	40	100
MSCPC105	LABORATORY II	60	40	100
Total		**320**	**380**	**700**

3rd Semester

PAPERS CODE	PAPERS NAME	INTERNAL	EXTERNAL	TOTAL
MSCPC101	PROPERTIES AND CHARACTERISATION METHODS OF POLYMERS	40	60	100
MSCPC102	SPECTROSCOPIC METHODS IN CHEMISTRY	40	60	100
MSCPC103	MOLECULAR SPECTROSCOPY	40	60	100
Practical				
MSCPC104	LABORATORY I	60	40	100
MSCPC105	LABORATORY II	60	40	100
Total		**240**	**260**	**500**

4th Semester

PAPERS CODE	PAPERS NAME	INTERNAL	EXTERNAL	TOTAL
MSCPC101	INORGANIC AND BIOPOLYMERS	40	60	100
MSCPC102	ADVANCES IN POLYMER SCIENCE AND TECHNOLOGY	40	60	100
MSCPC103	ANALYTICAL CHEMISTRY	40	60	100
Practical				
MSCPC104	MASTER THESIS			100
Total		**120**	**180**	**400**

MASTER OF SCIENCE

POLYMER CHEMISTRY

SEMESTER I

ORGANOMETALLICS AND NUCLEAR CHEMISTRY

Unit 1: Organometallic Compounds-Synthesis, Structure and Bonding

1.1 Hapto nomenclature of organometallic compounds, organometallic compounds with linear pi donor ligands-olefins, acetylenes, dienes and allyl complexes-synthesis, structure and bonding.

1.2 Synthesis and structure of complexes with cyclic pi donors, metallocenes and cyclic arene complexes, bonding in ferrocene and dibenzenechromium, carbene and carbyne complexes.

1.3 Metal carbonyls: CO as a π-bonding ligand, synergism, preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, metal nitrosyls, metal cyanides and dinitrogen complexes. Polynuclear metal carbonyls with and without bridging. Carbonyl clusters-LNCCS and HNCCS, Isoelectronic and isolobal analogy, Wade-Mingos rules, cluster valence electrons. IR spectral studies of bridging and non-bridging CO ligands.

Unit 2: Reactions of Organometallic Compounds

2.1 Substitution reactions: Nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands.

2.2 Addition and elimination reactions-1, 2 additions to double bonds, carbonylation and decarbonylation. Oxidative addition- concerted addition, S_N2, radical and ionic mechanisms. Reductive elimination- binuclear reductive elimination and σ-bond metathesis. Oxidative coupling and reductive decoupling. Insertion (migration) and elimination reactions – insertions of CO and alkenes, insertion into M—H versus M—R, α, β, γ and δ eliminations.

2.3 Redistribution reactions, fluxional isomerism of allyl, cyclopentadienyl and allene systems.

Unit 3: Catalysis by Organometallic Compounds (18 Hrs)

3.1 Homogeneous and heterogeneous organometallic catalysis: Tolman catalytic loops, alkene hydrogenation using Wilkinson catalyst.

3.2 Reactions of carbon monoxide and hydrogen-the water gas shift reaction, the Fischer-Tropsch reaction (synthesis of gasoline).

3.3 Hydroformylation of olefins using cobalt and rhodium catalysts.

3.4 Polymerization by organometallic initiators and templates for chain propagation-Ziegler Natta catalysts, polymerisation by metallocene catalysts.

3.5 Carbonylation reactions: Monsanto acetic acid process, olefin hydroformylation- oxo process, carbonylation of alkenes and alkynes in the presence of a nucleophile- the Reppe reaction. Carbonylation of aryl halides in the presence of a nucleophile.

3.6 Olefin methathesis-synthesis gas based reactions, photodehydrogenation catalyst ("Platinum Pop").

3.7 Oxidation of olefins: Palladium catalysed oxidation of ethylene-the Wacker process, epoxidation of olefins, hydroxylation by metal-oxo complexes
3.8 Asymmetric catalysis- Asymmetric hydrogenation, isomerisation and epoxidation.
3.9 C-H activation and functionalization of alkanes and arenes: Radical type oxidation, hydroxylation, dehydrogenation, carbonylation and regioselective borylation of alkanes and cycloalkanes. Radical type reactions, electrophilic reactions, carbonylation and borylation of arenes. Insertion of alkenes and alkynes in the Ar-H bond.
3.10 Application of palladium catalysts in the formation of C-O and C-N bonds, oxidative coupling reactions of alkynes with other unsaturated fragments for the formation of cyclic and heterocylic compounds. The Dötz reaction.

Unit 4: Bioinorganic Compounds (18 Hrs)
4.1 Essential and trace elements in biological systems, toxic effects of metals (Cd, Hg, Cr, Pb and as), structure and functions of biological membranes, mechanism of ion transport across membranes, sodium pump, ionophores, valinomycin. Phosphate esters in biology, Redox metalloenzymes, cytochromes-cytochrome P450.
4.2 Oxygen carriers and oxygen transport proteins: Structure and functions of haemoglobins and myoglobin, oxygen transport mechanism, cooperativity, Bohreffect. Structure and functions of haemerythrins and haemocyanin.
4.3 Biochemistry of zinc and copper: Structure and functions of carbonic anhydrase, carboxypeptidase A and superoxide dismutase.

4.4 Other important metal containing biomolecules: Vitamin B_{12} and the vitamin B_{12} coenzymes, photosynthesis-chlorophyll a, PS I and PS II.
4.5 Role of calcium in muscle contraction, blood clotting mechanism and biological calcification. Metals in medicine-therapeutic applications of cis-platin, radioisotopes and MRI agents.

Unit 5: Nuclear Chemistry
5.1 Nuclear Reactions: Q value and reaction threshold, reaction cross section, cross section and reaction rate, neutron capture cross section- variation of neutron capture cross section with energy (1/V law). Nuclear fission - fission fragments and mass distribution, fission yields, fission energy, fission cross section and threshold fission neutrons, nuclear fusion reactions and their applications.
5.2 Principles of counting technique: G.M. counter, proportional, ionization and scintillation counters, cloud chamber.
5.3 Synthesis of transuranic elements: Neptunium, Plutonium, Curium, Berkelium, Einsteinium, Mendelevium, Nobelium, Lawrencium
5.4 Analytical applications of radioisotopes-radiometric titrations, kinetics of exchange reactions, measurement of physical constants including diffusion constants, Radioanalysis, Neutron Activation Analysis, Prompt Gama Neutron Activation Analysis and Neutron Absorptiometry.
5.5 Radiation chemistry of water and aqueous solutions. Measurement of radiation doses. Relevance of radiation chemistry in biology, organic compounds and radiation polymerization.

STRUCTURAL AND MOLECULAR ORGANIC CHEMISTRY

Unit 1: Basic Concepts in Organic Chemistry

1.1 Review of basic concepts in organic chemistry: Bonding, hybridisation, MO picture of butadiene and allyl systems.

1.2 Electron displacement effects: Inductive effect, electromeric effect, resonance effect, hyperconjugation, steric effect. Bonding weaker than covalent bonds.

1.3 Concept of aromaticity: Delocalization of electrons - Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems - annulenes.
NMR as a tool, carbon nanotubes and graphene

1.4 Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples. Arenium ion intermediates. SN1, SNAr, SRN1 and benzyne mechanisms.

Unit 2: Physical Organic Chemistry

2.1 Energy profiles. Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples. Linear free energy relationships-Hammet equation, Taft equation.

2.2 Catalysis by acids, bases and nucleophiles with examples from acetal, cyanohydrin. Ester formation and hydrolysis reactions of esters-AAC2, AAC1, AAL1, BAC2and BAL1 mechanisms. Hard and soft acids, bases - HSAB principle and its applications (organic reactions only)

Unit 3: Organic Photochemistry

3.1 Photoreactions of carbonyl compounds: Norrish reactions of ketones. Patterno-Buchi reaction. Barton (nitrite ester reaction); Di-π-methane and Photo Fries rearrangements, photochemistry of conjugated dienes (butadiene only), photochemistry of vision.

Unit 4: Stereochemistry of Organic Compounds

4.1 Stereoisomerism: Definition based on symmetry and energy criteria, configuration and conformational stereoisomers, introduction to Akamppt isomerism(basic idea only)

4.2 Centre of chirality: Molecules with C, N, S based chiral centers, absolute configuration, enantiomers, racemic modifications, R and S nomenclature using Cahn-Ingold-Prelog rules, molecules with a chiral centre and Cn, molecules with more than one center of chirality, definition of diastereoisomers, constitutionally symmetrical and unsymmetrical chiral molecules, erythro and threo nomenclature.

4.3 Axial, planar and helical chirality with examples,stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidenecycloalkanes.

4.4 Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature, NMR distinction of enantiotropic/diastereotopic ligands.

4.5 Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers, interconversion of geometrical isomers.

Unit 5: Conformational Analysis

5.1 Conformational descriptors: Factors affecting conformational stability of

molecules,conformational analysis of substituted ethanes, cyclohexane and its derivatives, decalins, adamantane, norbornane,sucrose and lactose.
5.2 Conformation and reactivity of elimination (dehalogenation, dehydrohalogenation, semipinacolic deamination and pyrolytic elimination- Saytzeff and Hofmann eliminations),substitution and oxidation of 2_o alcohols.
5.3 Chemical consequence of conformational equilibrium - Curtin Hammett principle.

QUANTUM CHEMISTRY AND GROUP THEORY

Unit 1: Group Theory and Applications in Chemical Bonding
1.1. Symmetry elements and symmetry operations.
1.2. Determination of point groups of molecules and ions (organic / inorganic / complex) belonging to C_n, C_s, C_i, C_{nv}, C_{nh}, $C_{\infty v}$, D_{nh}, $D_{\infty h}$, D_{nd}, T_d and O_h point groups.
1.3. Symmetry in crystals: 32 crystallographic point groups (no derivation), Hermann-Mauguin symbols. Screw axis-pitch and fold of screw axis, glide planes, space groups(elementary idea only)
1.4. Mathematical groups: Properties, Abelian groups, cyclic groups, sub groups, similarity transformation ,classes - C_{2v}, C_{3v} and C_{2h}.
1.5. Group multiplication tables (GMTs) - C_{2v}, C_{3v} and C_{2h}, isomorphic groups.
1.6. Matrix representation of elements like E, Cn, Sn, i, σ-matrix representation of point groups like C_{2v},C_{3v},C_{2h},C_{4v} - trace /character, block factored matrices.
1.7. Reducible and irreducible representations, standard reduction formula, statement of great orthogonality theorem (GOT), construction of character tables for C_{2v}, C_{2h}, C_{3v} and C_{4v}.
1.8. Application in chemical bonding: Projection operator, transformation properties of atomic orbitals, construction of symmetry adapted linear combination of atomic orbitals (SALCs) of C_{2v}, C_{3v}, D_{3h} and C_{2h} molecules.

Unit 2: Quantum Mechanics and Applications
2.1. Experimental foundation of quantum mechanics: Elementary ideas of black body radiation, photoelectric effect and atomic spectra. Need of quantum mechanics. Concept of matter wave, de Broglie relation, uncertainty principle and its consequences.
2.2. Postulates of Quantum Mechanics: State function or wave function postulate: Born interpretation of the wave function, well behaved functions, orthonormality of wave functions. Operator postulate: Operator algebra, linear and nonlinear operators, Laplacian operator, commuting and noncommuting operators, Hermitian operatorsand their properties, eigen functions and eigen values of an operator. Eigen value postulate: eigen value equation, eigen functions of commuting operators. Expectation value postulate. Postulate of time-dependent Schrödinger equation, conservative systems and time-independent Schrödinger equation.
2.3. Translational motion: Free particle in one-dimension, particle in a one dimensional box with infinite potential walls, particle in a one-dimensional box with finite potential walls-tunneling, particle in a three-dimensionalbox ,separation of variables, degeneracy.
2.4. Vibrational motion: One-dimensional harmonic oscillator (complete treatment), Hermite equation(solving by method of power series), Hermite polynomials,

recursion relation, wave functions and energies-important features, harmonic oscillator model and molecular vibrations.
2.5. Rotational motion: Co-ordinate systems, cartesian, cylindrical polar and spherical polar coordinates and their relationships. The wave equation in spherical polar coordinates-particle on a ring, the phi equation and its solution, wave functions in the real form. Non-planar rigid rotor (or particle on a sphere), separation of variables, the phi and the theta equations and their solutions, Legendre and associated Legendre equations, Legendre and associated Legendre polynomials. Spherical harmonics (imaginary and real forms), polar diagrams of spherical harmonics.
2.6. Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta (Lx, Ly, Lz and L_2), commutation relations between these operators. Spherical harmonics as eigen functions of angular momentum operators Lz and L_2. Ladder operator method for angular momentum, space quantization.
2.7. Quantum Mechanics of Hydrogen-like Atoms: Potential energy of hydrogen-like systems. The wave equation in spherical polar coordinates: separation of variables-r, theta and phi equations and their solutions, wave functions and energies of hydrogenlike atoms. Orbitals: Radial functions, radial distribution functions, angular functions and their plots. Dirac's relativistic equation for hydrogen atom (Elementary idea only).
2.8. Spin orbitals: Construction of spin orbitals from orbitals and spin functions, spin orbitals for many electron atoms, symmetric and antisymmetric wave functions. Pauli's exclusion principle, slater determinants.

THERMODYNAMICS, KINETIC THEORY AND STATISTICAL THERMODYNAMICS

Unit 1: Classical Thermodynamics
1.1 Mathematical foundations for thermodynamics-variables of thermodynamics, extensive and intensive quantities, equation for total differential, conversion formulas, exact differentials-general formulation, reciprocity characteristics, homogeneous functions, Euler’s theorem. (Non-evaluative)
1.2 Thermodynamic equations of state. Maxwell relations and significance, irreversible processes - Clausius inequality.
1.3 Free energy, thermodynamic equilibria and free energy functions, temperature dependence of free energy - Gibbs Helmholtz equation, applications of Gibbs Helmholtz equation.
1.4 Partial molar quantities, chemical potential and Gibbs-Duhem equations, variation of chemical potential with temperature and pressure, determination of partial molar volume and enthalpy.
1.5 Fugacity, relation between fugacity and pressure, determination of fugacity of a real gas, variation of fugacity with temperature and pressure. Activity, dependence of activity on temperature and pressure.
1.6 Thermodynamics of mixing, Gibbs-Duhem-Margules equation, applications of Gibbs-Duhem- Margules equation- Konovalov’s first and second laws, excess thermodynamic functions-free energy, enthalpy, entropy and volume, determination of excess enthalpy and volume.
1.7 Chemical affinity and thermodynamic functions, effect of temperature and pressure on chemical equilibrium- Vant Hoff reaction isochore and isotherm.1.8 Third law of thermodynamics, Nernst heat theorem, determination of absolute

entropies using third law.
1.9 Three component systems-graphical representation. Solid-liquid equilibria, ternary solutions with common ions, hydrate formation, compound formation. Liquid-liquidequilibria-one pair of partially miscible liquids, two pairs of partially miscible liquids, three pairs of partially miscible liquids.

Unit 2: Kinetic Theory of Gases
2.1 Derivation of Maxwell's law of distribution of velocities, graphical representation, experimental verification of the law, most probable velocity, derivation of average, RMS and most probable velocities, collision diameter, collision frequency in a single gas and in a mixture of two gases, mean free path, frequency of collision, effusion, the rate of effusion, time dependence of pressure of an effusing gas, the law of corresponding states, transport properties of gases.

Unit 3: Statistical Thermodynamics
3.1 Brief history about the macroscopic and microscopic approach in science, permutation, probability, Stirling's approximation, macrostates and microstates, equal-apriori principle and thermodynamic probability, phase-space, ensemble, types of ensembles.
3.2 Boltzmann distribution law, partition function and its physical significance, relation between molecular partition function and molar partition function, distinguishable and indistinguishable particles, partition function and thermodynamic functions, separation of partition function-translational, rotational, vibrational, and electronic partition functions, partition function for hydrogen. Thermal de-Broglie wavelength
3.3 Calculation of thermodynamic functions and equilibrium constants, thermodynamic probability and entropy, Sakur-Tetrode equation, statistical formulation of third law of thermodynamics, residual entropy, heat capacity of gases - classical and quantum
3.4 Need for quantum statistics, Bosons and Fermions, Bose-Einstein statistics: Bose-Einstein distribution law, Bose-Einstein condensation, first order and higher order phase transitions, liquid helium, Fermi- Dirac statistics: Fermi- Dirac distribution law, application in electron gas, thermionic emission. Comparison of three statistics.
3.5 Heat capacity of solids- the vibrational properties of solids, Einstein's theory and its limitations, Debye theory and its limitations.

MORPHOLOGY AND PHYSICAL CHEMISTRY OF POLYMERS

Unit 1: MOLECULAR WEIGHT: (15)
Concept of molecular mass, polydisperse nature and degree of polymerization, number average,
weight average, viscosity average molecular weights and their statistical equations, molecular weight distribution. Determination of molecular weights of polymers by vapour phase osmometers, end group analysis, light scattering, viscometry and G P C. Polymer conformation
and chain dimensions, freely jointed chains, real chains, characteristic ratio.

Unit 2: MORPHOLOGY OF POLYMERS: (15)
Crystalline and amorphous phase, factors affecting polymer crystallinity, XRD analysis for

polymer crystallinity, crystallites, amorphous regions, spherulites, single crystal, fibrils, Orientation, transitions, glass transition temperature (Tg), factors affecting Tg, determination of

Tg, TMA and DSC (Principles of TMA and DSC expected).

Unit 3: POLYMER SOLUTIONS: (15)
Stages and thermodynamics of polymers dissolution, heat of dissolution and solubility parameter, Flory- Huggins theory of polymer solutions, Krigbaun- Flory theory, mean field theory of Flory, viscosity of dilute solution.

Unit 4: DEGRADATION AND STABILIZATION: (15)
Processes involved in degradation of natural and synthetic polymers, mechanism of degradation
by mechanical, chemical, thermal and radiation (high energy, photo, ultrasonic) agencies, ceiling
temperature, polymer stabilization, antioxidant, photo stabilizers.

LABORATORY I

LABORATORY II

SEMESTER II

COORDINATION CHEMISTRY

Unit 1: Structural Aspects and Bonding

1.1 Classification of complexes based on coordination numbers and possible geometries, sigma and pi bonding ligands such as CO, NO, CN^-, R_3P, and Ar_3P. Stability of complexes, thermodynamic aspects of complex formation-Irving William order of stability, chelate effect.

1.2 Splitting of d orbitals in octahedral, tetrahedral, square planar, square pyramidal and triagonal bipyramidal fields, LFSE, Dq values, Jahn Teller (JT) effect, theoretical failure of crystal field theory, evidence of covalency in the metal-ligand bond, nephelauxetic effect, ligand field theory, molecular orbital theory- M.O energy level diagrams for octahedral and tetrahedral complexes without and with π-bonding,
experimental evidences for pi-bonding.

Unit 2: Spectral and Magnetic Properties of Metal Complexes

2.1 Electronic Spectra of complexes: Term symbols of d^n system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields, correlation diagrams for d^1 and d^9 ions in octahedral and tetrahedral fields (qualitative approach), d-d transitions, selection rules for electronic transitions-effect of spin orbit coupling and vibronic coupling.

2.2 Interpretation of electronic spectra of complexes: Orgel diagrams and demerits, Tanabe Sugano diagrams, calculation of Dq, B and β (Nephelauxetic ratio) values,
spectra of complexes with lower symmetries, charge transfer spectra, luminescence spectra.

2.3 Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, spin only magnetic moment. Temperature dependence of magnetism- Curie's law, Curie-Weiss law, temperature independent paramagnetism (TIP), spin state cross over, antiferromagnetism-inter and intra molecular interaction, anomalous magnetic moments.

Unit 3: Kinetics and Mechanism of Reactions in Metal Complexes

3.1 Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic substitution reactions in square planar complexes- trans effect-theory and applications, effect of entering ligand, effect of leaving group and effect of ligands already present on reaction rate, effect of solvent and reaction pathways, substitution in tetrahedral and five-coordinate complexes.

3.2 Kinetics and mechanism of octahedral substitution- water exchange, dissociative and associative mechanisms, base hydrolysis, racemization reactions, solvolytic reactions (acidic and basic). Replacement reactions involving multidentate ligands- formation of chelates, effect of H^+ on the rates of substitution of chelate complexes, metal ion assisted and ligand assisted dechelation.

3.3 Electron transfer reactions: Outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism, mixed outer and inner sphere reactions, two electron transfer and intramolecular electron transfer.

Unit 4: Stereochemistry of Coordination Compounds
4.1 Geometrical and optical isomerism in octahedral complexes, resolution of optically active complexes, determination of absolute configuration of complexes by ORD and circular dichroism, stereoselectivity and conformation of chelate rings, asymmetric synthesis catalysed by coordination compounds,
4.2 Linkage isomerism: Electronic and steric factors affecting linkage isomerism, symbiosis-hard and soft ligands, Prussian blue and related structures, Macrocycles-crown ethers.

Unit 5: Coordination Chemistry of Lanthanoids and Actinoids
5.1 Term symbols for lanthanide ions, inorganic compounds and coordination complexes of the lanthanoids upto coordination No.12, electronic spectra and magnetic properties of lanthanoid complexes, organometallic complexes of the lanthanoids- σ-bonded complexes, cyclopentadienyl complexes, organolanthanoid complexes as catalysts.
5.2 General characteristics of actinoids-difference between 4f and 5f orbitals, coordination complexes of the actinoids- sandwich complexes, coordination complexes and organometallic compounds of thorium and uranium, comparative account of coordination chemistry of lanthanoids and actinoids with special reference to electronic spectra and magnetic properties.

ORGANIC REACTION MECHANISMS

Unit 1: Review of Organic Reaction Mechanisms
1.1 Review of organic reaction mechanisms with special reference to nucleophilic and electrophilic substitution at aliphatic carbon (SN_1, SN_2, SN_i, SE_1, SE_2), elimination (E_1 and E_2) and addition reactions (regioselectivity: Markovnikov's additioncarbocation mechanism, anti-Markovnikov's addition-radical mechanism).
Elimination *vs* substitution.
1.2 A comprehensive study on the effect of substrate, reagent, leaving group, solvent and neighbouring group on nucleophilic substitution(SN_2 and SN_1) and elimination (E_1 and E_2) reactions.

Unit 2: Chemistry of Carbanions
2.1 Formation, structure and stability of carbanions; Reactions of carbanions: C-X bond (X = C, O, N) formations through the intermediary of carbanions. Chemistry of enolates and enamines. Kinetic and Thermodynamic enolates- lithium and boron enolates in aldol and Michael reactions, alkylation and acylation of enolates.
2.2 Nucleophilic additions to carbonyls groups: Name reactions under carbanion chemistry-mechanism of Claisen, Dieckmann, Knoevenagel, Stobbe, Darzen and acyloin condensations, Shapiro reaction and Julia elimination. Favorski rearrangement.
2.3 Ylids: chemistry of phosphorous and sulphurylids - Wittig and related reactions, Peterson olefination.

Unit 3: Chemistry of Carbocations
3.1 Formation, structure and stability of carbocations. Classical and non-classical carbocations.
3.2 C-X bond (X = C, O, N) formations through the intermediary of carbocations.

Molecular rearrangements including Wagner-Meerwein, Pinacol-pinacolone, Semipinacol, Dienone-phenol and Benzilic acid rearrangements, Noyori annulation, Prins reaction.
3.3 C-C bond formation involving carbocations: Oxymercuration, Halolactonisation.

Unit 4: Carbenes, Carbenoids, Nitrenes and Arynes
4.1 Structure of carbenes (singlet and triplet), generation of carbenes, addition and insertion reactions.
4.2 Reactions of carbenes such as Wolff rearrangement, Reimer-Tiemannreaction. Reactions of ylides by carbenoid decomposition
4.3 Structure, generation and reactions of nitrene and related electron deficient nitrene intermediates.
4.4 Hoffmann, Curtius, Lossen, Schmidt and Beckmann rearrangement reactions.
4.5 Arynes: Generation, structure, stability and reactions. Orientation effect - amination of haloarenes.

Unit 5: Radical Reactions
5.1 Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter and intramolecular) for C-C bond formation - Baldwin's rules (b) fragmentation and rearrangements - Hydroperoxide: formation, rearrangement and reactions. Autooxidation.
5.2 Name reactions involving radical intermediates: Barton deoxygenation and decarboxylation, McMurry coupling.

Unit 6: Chemistry of Carbonyl Compounds
6.1 Reactions of carbonyl compounds: Oxidation, reduction (Clemmensen and Wolf-Kishner), addition (addition of cyanide, ammonia, alcohol) reactions, Aldol condensation, Cannizzaro reaction, Addition of Grignard reagent. Structure and reactions of α, β - unsaturated carbonyl compounds involving electrophilic and nucleophilic addition - Michael addition, Mannich reaction, Robinson annulation.

Unit 7: Concerted reactions
7.1 Classification: Electrocyclic, sigmatropic, cycloaddition, chelotropic,ene and dyotropic reactions. Woodward Hoffmann rules - Frontier orbital and orbital symmetry correlation approaches - PMO method (for electrocyclic and cycloaddition reactions only).
7.2 Highlighting pericyclic reactions in organic synthesis such as Claisen, Cope, Wittig, Mislow-Evans and Sommelet-Hauser rearrangements. Diels-Alder and Ene reactions (With stereochemical aspects), dipolar cycloaddition (introductory).
7.3 Unimolecular pyrolytic elimnination reactions: Cheletropic elimination, decomposition of cyclic azo compounds, β-eliminations involving cyclic transition states such as N-oxides (Cope reaction), Acetates and Xanthates (Chugaeve reaction).

CHEMICAL BONDING AND COMPUTATIONAL CHEMISTRY

Computational chemistry is a branch of chemistry that uses computer simulation to assist in solving complex chemical problems. It exploits methods of theoretical chemistry, incorporated into efficient computer programs, to calculate the structures, the interactions, and the properties of molecules

Chemical and physical changes: chemistry is largely concerned with the properties and reactions of substances. Properties are often classed as physical (colour, melting temperature ...) and chemical (which substances are reacted with, under what conditions, to give which products).

We have identified seven concepts that are highly useful in a wide range of Scratch projects, and which transfer to other programming (and non-programming) contexts: sequences, loops, parallelism, events, conditionals, operators, and data.

The field of computational chemistry was not widely considered a distinct field of study until Pople and Kohn won the Nobel Prize in Chemistry in 1998 for their work on computational models in quantum chemistry and density-functional theory respectively.

STEP-GROWTH POLYMERS

Unit 1: (15)
(A) POLYESTERS AND POLYCARBONATE:
History, synthetic methods, manufacture of PBT, PEN, Sarona (from 1, 3-propanediol and DMT)
Unsaturated and Saturated Network polymers. Synthetic methods, properties and applications of
Aromatic polycarbonates.
(B) POLYAMIDES
Developments of Nylons, Nomenclature, synthetic methods, Nylon-6, Nylon-7, Nylon-11, Aromatic polyamides (Kevlar, Nomex).
Unit 2: (15)
(A) POLYIMIDES:
Polyimides, addition type polyimides, polybenzimidazoles.
(B) POLYARYLENE ETHERS:
Synthesis, properties and applications of polysulfones, polyketones, polyethers. Polyetherketones,
Polyether-ether-ketones, polyphenylenes.
Synthesis, properties and applications of polyurethane elastomers and foams.
Unit 3: FORMALDEHYDE BASED POLYMERS: (15)
Phenol-formaldehyde (PF) resin, novolac and resol type, factors affecting the prepolymer structure, mechanism of prepolymer formation, crosslinking of novolacs and resols, properties
and applications of PF resin. Melamine formaldehyde (MF) resin, basic reactions, modification of
MF prepolymer, crosslinking reactions in MF, properties and applications of MF resin. Urea formaldehyde
(UF) resin, synthesis of UF prepolymer; crosslinking, mechanism, properties and applications of UF resin.
Unit 4: THERMOSETTING EPOXY RESINS : (15)
General chemistry of bisphenol-A based expoxy resins, chemistry, properties and applications of
cycloaliphatic epoxy resins, chemistry, properties and applications of epoxy, novolac, flexible

epoxy and flame retardant epoxy resins, commercial epoxy resin curing agents. Cyanate esters,bismaleimides, polybenzoxazines.

LABORATORY I

LABORATORY II

SEMESTER III

PROPERTIES AND CHARACTERISATION METHODS OF POLYMERS

Unit 1: Morphology and Order in Crystalline Polymers

1.1 Polymer morphology: Common polymer morphologies, structural requirements for crystallinity, degree of crystallinity, crystallisability-mechanism of crystallisation.

1.2 Polymer single crystals: Lamellae, complex structures, disorder and nature of the fold surfaces.

1.3 Structure of polymers crystallized from melt: The fringed micelle concept, the defect structure of crystalline polymers, extended-chain crystals, structure of spherulites, relation of sherulites to crystallites, morphology of sperulites.

1.4 Theory of crystallisation: Avrami equation, Hoffman's nucleation theory, the entropic barrier theory.

1.5 Strain induced morphology: Fibrillar crystallisation, cold drawing, morphology changes during orientation, degree of orientation-X-ray diffraction, birefringes, infrared dichroism.

1.6 Morphological analysis: Optical microscopy, electron microscopy (SEM and TEM), atomic force microscopy.

Unit 2: Polymer Solutions

2.1 Criteria for polymer solubility: Solubility, polymer texture and solubility, the concept of solubility parameter, Hildebrand solubility parameter and its application.

2.2 Thermodynamics of polymer solution: Flory-Huggins theory(liquid lattice theory), modified Flory-Huggins theory, entropy of mixing, enthalpy and free energy of mixing, dilute polymer solutions (Flory-Krigbaum theory), advantages and limitation of FH and FK theories, corresponding state theories.

2.3 Phase Equilibrium: Polymer-solvent miscibility, binary polymer-solvent systems, ternary systems, multicomponent systems, polymer-polymer miscibility,

2.4 Fractionation of polymers by solubility: Bulk fractionation by nonsolvent addition, column elution-solvent gradient elution, thermal gradient elution, analytical precipitation techniques-summative fractionation, turbidimetric titration.

2.5 Conformations of polymer chain in solution: End-to-end dimension, the freely joined chain, real polymer chains, fixed bond angle-freely rotating, fixed bond anglerestricted rotation, long range interactions.

Unit 3: Properties and Testing of Polymers

3.1 Testing: Overview of various testing methods and standards such as ASTM, BIS and ISO. Test specimen preparation-milling, punching, template, cutting from sheets or films product.

3.2 Mechanical properties of polymers: Stress-strain properties in tension, tensile strength, fatigue tests, flexural strength, impact tests, tear resistance, hardness,

abrasion resistance, creep and stress relaxation, dynamic mechanical analysis (DMA), Young's modulus, polymer fracture behaviour-brittle fracture, linear elastic fracture mechanics. Hardness test methods- principle of hardness testing, conventional hardness testing methods, test methods for determining hardness values after unloading, test methods for determining hardness values under load, comparability of hardness values, instrumented hardness test-fundamentals of measurement methodology, material parameters derived from instrumented hardness tests. Quasi-static test methods-deformation behaviour of polymers, tensile tests on polymers-theoretical basis of the tensile test, conventional tensile tests, enhanced information of tensile tests, tear test, compression test on polymers-theoretical basis of the compression test, performance and evaluation of compression tests, bend tests on polymers-theoretical basis of the bend best.
3.3 Thermal properties: Thermal conductivity, thermal expansion, heat capacity, heat deflection temperature, vicat softening temperature, torsion pendulum test, glass transition temperature.
3.4 Electrical properties: Dielectric strength, short time method, slow rate of rise method, step by step method, dielectric constant and dissipation factor, arc resistance test. Conducting polymers-conduction mechanism, applications of conducting polymers with examples, polymers with piezo, pyro, ferro electric characters.
3.5 Optical properties: transmittance and reflectance, gloss, haze, transparency, refractive index.
3.6 Polymer viscoelasticity: Introduction, simple rheological responses-the ideal elastic response, pure viscous flow, rubberlike elastic, viscoelasticity-mechanical models for linear viscoelastic response, Maxwell model-creep experiment, stress relaxation experiment, dynamic experiment, the Voight element, the four-parameter model, material response time-the Deborah Number, relaxation and retardation

spectra, Maxwell-Weichert model (relaxation), Voight-Kelvin (creep) model, superposition principle-Boltzmann superposition principle, time-temperature superposition principle.

Unit 4: Characterisation Methods of Polymers

4.1 Polymer molecular weight characterization: Molecular weight distribution, number average molecular weight determination-osmometry techniques, end group analysis, colligative property measurements. Weight average molecular weight determination-light scattering technique, sedimentation technique, higher average molecular weight determination-gel permeation chromatography (GPC), viscosity average molecular weight (Mŋ) determination-viscometry, ultracentrifugation.
4.2 Spectroscopic methods of characterization: Vibrational spectroscopy methods-IR, Raman spectroscopy. Resonance method-NMR spectroscopy, diffusion-ordered NMR spectroscopy (DOSY). Electronic spectroscopy methods- UV/visible spectroscopy, fluorescence, electron spin resonance (ESR). Scattering spectroscopy methods-X-ray diffraction, X-ray crystallography, small angle neutron scattering. Mass spectroscopy method characterization, molecular relaxation spectroscopy-X-ray and neutron scattering methods.
4.3 Microscopy methods: Transmission electron microscopy (TEM), scanning electron microscopy (SEM).
4.4 Thermo-analytical methods: Differential scanning calorimetry (DSC), differential thermal analysis (DTA), thermo-mechanical analysis, thermo-gravimetric analysis.

Unit 5: Polymer Waste Management

5.1 Analysis of polymer wastes: Fluorescence labelling, time-gated fluorescence spectroscopy, identification of black plastics, life cycle assessment, analysis of contaminated mixed waste plastics, application of Raman spectroscopy in waste analysis, SPI codes.
5.2 Management: Source reduction, product reuse, durable products, recycling of plastic wastes, plastic waste to energy, landfilling of waste plastics, alternative plastic materials.
5.3 Polymer recycling: Recycling codes, mechanical recycling-primary and secondary, chemical recycling-tertiary recycling, quaternary recycling- thermal utilisation, renewable polymer synthesis, sustainable bio-plastic production through landfill methane recycling.
5.4 Biodegradable polymers, degradation products in degradable polymers, recycling BIOPOL-composting, laboratory-scale composting, test methods to determinepolymer biodegradability, synthesis and applications of photodegradable poly (Ethylene terephthalate).

SPECTROSCOPIC METHODS IN CHEMISTRY

Unit 1: Ultraviolet-Visible and Chirooptical Spectroscopy
1.1 Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules.
1.2 Influence of substituent, ring size and strain on spectral characteristics. Solvent effect, Stereochemical effect, non-conjugated interactions. Chirooptical properties ORD, CD, octant rule, axial haloketone rule, cotton effect-applications.
1.3 Problems based on the above topics.
Unit 2: Infrared Spectroscopy
2.1 Fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions), influence of substituent, ring size, hydrogen bonding, vibrational coupling and field effect on frequency, determination of stereochemistry by IR technique.
2.2 IR spectra of C=C bonds (olefins and arenes) and C=O bonds.
2.3 Problems on spectral interpretation with examples.

Unit 3: Nuclear Magnetic Resonance Spectroscopy
3.1 Magnetic nuclei with special reference to 1H and 13C nuclei. Chemical shift and shielding/deshielding, factors affecting chemical shift, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy. $_1$H and $_{13}$C NMR scales.
3.2 Spin-spin splitting: AX, AX_2, AX_3, A_2X_3, AB, ABC, AMX type coupling, first order and non-first order spectra, Pascal's triangle, coupling constant, mechanism of coupling- Dirac model. Karplus curve, quadrupole broadening and decoupling, homotopic, enantiotropic and diastereotopic protons, virtual coupling, long range coupling. NOE and cross polarization.
3.3 Simplification non-first order spectra to first order spectra: shift reagents, spin decoupling and double resonance, off resonance decoupling. Chemical shifts and homonuclear/heteronuclear couplings. Basis of heteronuclear decoupling.
3.4 2D NMR and COSY, HOMOCOSY and HETEROCOSY
3.5 Polarization transfer. Selective Population Inversion. DEPT. Sensitivity enhancement and spectral editing. MRI.
3.6 Problems on spectral interpretation with examples

Unit 4: Mass Spectrometry

4.1 Molecular ion: Ion production methods (EI). Soft ionization methods: SIMS, FAB, CA, MALDI-TOF, PD, Field Desorption Electrospray Ionization. Fragmentation patterns (polyenes, alkyl halides, alcohols, phenols, aldehydes and ketones, esters). Nitrogen and ring rules. McLafferty rearrangement and its applications. HRMS, MSMS, LC-MS, GC-MS.

4.2 Problems on spectral interpretation with examples.

Unit 5: Structural Elucidation Using Spectroscopic Techniques

5.1 Identification of structures of unknown organic compounds based on the data from UV-Vis, IR, 1H NMR and 13C NMR spectroscopy (HRMS data or Molar mass or molecular formula may be given).

5.2 Interpretation of the given UV-Vis, IR and NMR spectra.

5.3 Spectral analysis of the following reactions/functional transformations:

a. Pinacol-Pinacolone rearrangement

b. Benzoin condensation

c. (4+2) cycloaddition

d. Beckmann rearrangement

e. Cis-trans isomerisation of azo compounds

f. Benzil-benzilic acid rearrangement

g. Fries rearrangement

MOLECULAR SPECTROSCOPY

Unit 1: Foundations of Spectroscopic Techniques

1.1. Regions of the electromagnetic radiation, origin of spectrum, intensity of absorption, signal to noise ratio, natural line width. Doppler broadening, Lamb dip spectrum, Born Oppenheimer approximation.

Unit 2: Microwave Spectroscopy

2.1 Principal moments of inertia and classification (linear, symmetric tops, spherical tops and asymmetric tops), selection rules, intensity of rotational lines, relative population of energy levels, derivation of J_{max}, effect of isotopic substitution, calculation of intermolecular distance, spectrum of non rigid rotors.

2.2 Rotational spectra of polyatomic molecules, linear and symmetric top molecules. Stark effect and its application, nuclear spin and electron spin interaction, chemical analysis by microwave spectroscopy.

Unit 3: Infrared and Raman Spectroscopy

3.1 Morse potential energy diagram, fundamental vibrations, overtones and hot bands, determination of force constants, diatomic vibrating rotator, breakdown of the Born-Oppenheimer approximation, effect of nuclear spin.

3.2 Vibrational spectra of polyatomic molecules, normal modes of vibrations, combination and difference bands, Fermi resonance. FT technique, introduction to FTIR spectroscopy. Instrumentation of FTIR

3.3 Scattering of light, polarizability and classical theory of Raman spectrum, rotational and vibrational Raman spectrum, complementarities of Raman and IR spectra, mutual exclusion principle, polarized and depolarized Raman lines, resonance Raman scattering and resonance fluorescence.

Unit 4: Electronic Spectroscopy

4.1 Term symbols of diatomic molecules, electronic spectra of diatomic molecules, selection rules, vibrational coarse structure and rotational fine structure of electronic spectrum. Franck-Condon principle, predissociation, calculation of heat of dissociation, Birge and Sponer method.

4.2 Electronic spectra of polyatomic molecules, spectra of transitions localized in a bond or group, free electron model. Different types of lasers-solid state lasers, continuous wave lasers, gas lasers and chemical laser, frequency doubling, applications of lasers.

Unit 5: Nuclear Magnetic Resonance Spectroscopy

5.1 Theory of NMR Spectroscopy: Interaction between nuclear spin and applied magnetic field, important magnetically active nuclei. Nuclear energy levels, population of energy levels, Larmor precession, relaxation methods. Chemical shift and its representation- δ scale of PMR and CMR. Spin-spin coupling: Theory and illustration with AX system.

5.2 Fourier Transformation (FT) NMR Spectroscopy: Instrumentation of NMR technique, magnets, probe and probe tuning, Creating NMR signals, effect of pulses, rotating frame reference, FID, FT technique, data acquisition and storage. Pulse sequences-Pulse width, spins and magnetisation vector.

5.3 Solid state NMR-Applications. Magic Angle Spinning(MAS).

Unit 6: Other Magnetic Resonance Techniques

6.1 EPR Spectroscopy: Electron spin in molecules, interaction with magnetic field, g factor, factors affecting g values, determination of g values ($g_{\parallel}$ and $g_{\perp}$), fine structure and hyperfine structure, Kramers' degeneracy, McConnell equation.

6.2 Theory and important applications of NQR Spectroscopy.

6.3 Mossbauer Spectroscopy: Principle, Doppler effect, recording of spectrum, chemical shift, factors determining chemical shift, application to metal complexes.

LABORATORY I

LABORATORY II

SEMESTER IV

INORGANIC AND BIOPOLYMERS

Unit 1. (15)
Phosphorous nitrogen polymers, introduction and structural chemistry, synthesis and reactions,
polymer chemistry.
Boron polymers, boron –nitrogen, boron-phosphorous, boron-oxygen, boron-carbon, boronhydrogen polymers.
Silicon polymers, preparation and properties, coordination polymers, Natural and synthetic coordination polymers, reactions, polyanions and polymeric hydroxides.
Unit 2: (15)
Types of naturally occuring sugars deoxysugars, aminosugars, branched chain sugars, sugar methyl ethers and acid derivatives of sugars. General methods of structure and ring size determination with particular reference to maltose, lactose, starch and cellulose: photosynthesis
of carbohydrates, metabolism of glucose, Glycoside-Anygdalin.
Classification, synthesis and properties of amino acids. Modern methods of peptide synthesis, sequence determination. Chemistry of insulin and oxytocin. Protein: structure, conformation and
properties. Enzyme: Kinetics, inhibition mechanism, structure and regulations.
Unit 3: (15)
Classification and biological importance of Lipids. Chemical synthesis of simple phospholipids.
Statistical mechanics of biopolymers: chain configuration of macromolecules, statistical distribution, end to end dimensions, calculation of average dimensions for various chain structures.
Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophilic forces, dispersion force interactions.
Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium.
Unit 4: (15)
Synthetic and Natural polymers, blends, composites in medical devices, Physical and Chemical
properties of biomedical polymers and their characterization, processing techniques to prepare
scaffolds, implants, micro / nanoparticles, cell and biomaterial interactions and applications and
examples. Drug containing nanofibers for biomedical applications.

ADVANCES IN POLYMER SCIENCE AND TECHNOLOGY

Unit 1: Specialty Polymers

1.1 Poly electrolytes-water soluble charged polymers, ionomers (ion containing polymers), conducting polymers, solid polymer electrolytes (SPE), electroluminescent polymers, fluoropolymers, block copolymers(multiphase polymers), polymer colloids, thermoplastic elastomers(TPE), polyblends (heterogeneous plastics), inter penetrating network (IPN) polymers, thermally stable polymers, telephonic polymers (Functional polymers) polymer microgel, biomedical polymers.

1.2 Liquid crystalline polymers: Definition and synthesis, main chain liquid crystalline polymers, side chain liquid crystalline polymers, combined side chain- main chain liquid crystalline polymers, liquid crystalline polymer networks, liquid crystalline elastomers, application of liquid crystalline polymers.

1.3 Dendritic polymers: Origin of dendrimers, structure, properties, design and synthesis divergent
growth method, convergent growth method, medicinal application.

1.4 Introduction to: Polymers for organic light-emitting diodes (OLEDs), organic and hybrid solar cell, supramolecular polymer science.

Unit 2: Adhesives and Surface Coating

2.1 Adhesives: Introduction, theory, surface treatment, joint design, physical nature of adhesives, types of adhesives, natural glues, applications, elastomer adhesives, synthetic adhesives, olefinic polymer adhesives, types of epoxy adhesives, inorganic adhesives, bio adhesives, test methods in determining the strength and properties of adhesives.

2.2 Surface coating: Introduction, types of coating, drying oils, types of resins, surfactants, surface preparation, solvent selection, methods of coating, theory of powder coating, application of powder coating, curving process. Corrosion, electroplating, hazards and safety measures in paint industry.

Unit 3: Polymer Blends and Composites

3.1 Polymer blends: Classification, principles and methods involved in the preparation of different polymer blends, study of polymer blends and alloys on the basis of miscibility, criteria for selection of polymer. Compatibility of blends-principles of solubility and compatibility, thermodynamics of miscibility, mechanical compatibility. Phase morphology-Phase separation behaviour, morphology of blends and its determination- electron microscopy- domain structure.

3.2 Introduction to rheology of polymer blends: Relevance in processing, rheology–phase morphology relationships and their relevance, micro rheology, rheological models-solution, and suspension models.

3.3 Industrial applications of polymer blends.

3.4 Polymer composites: Fundamental concepts, factors influencing the performance of polymer composites-aspect ratio, void content, length of the fibre, nature of the fibre. Structure property relationship between fibre and matrix, modifications of the fibre surface, degree of interaction between fibre and matrix, wetting behaviour, degree of cross linking etc.,

3.5 Processing of thermoplastic composites: Types of processing methods, solution, film, lamination, sandwich etc., processing conditions, advantages and disadvantages.

3.6 Fabrications of thermoset composites: Hand layup method, compression and transfer moulding, pressure and vacuum bag process, filament winding, protrusion, reinforced RIM, RRIM, injection moulding of thermosets, SMC and DMC.

3.7 Nano-composites: Definition, types, methods of fabrication, characterization. Polymer/CNTs and Polymer/Nanoclay based composites, properties and their functional applications.

Unit 4: Polymer Compounding and Processing (18 Hrs)
4.1 Polymer mixing: Introduction, basic concepts, mechanism of mixing and dispersion, mixing of solid-solid, liquid-liquid and liquid-solid, dispersive mixing, distributive mixing and laminar mixing, mixing indices, kinetics of mixing, rheology of filled polymers.
4.2 Compounding: Introduction, types and characteristics of compounds-polymer blends, polymer formulations, filled polymers and polymer composites, compounding practice, mixing types, solid additives, morphology of filler additives, compatibilizers-mechanism and theory, filler surface modification and interfacial agents, dispersion of polymer nanoparticles in polymer melt, fillers and reinforcements *viz*. carbon black, ZnO, calcium carbonate, titanium oxide, nano clay, glass fibers, organic fillers, nanofillers. Compounding ingredients for rubber-fillers, reinforcing, semi reinforcing and nonreinforcing, peptizers, vulcanizing agents, activators, accelerators, anti-oxidants, antiozonants, pigments, tackifiers, blowing agents, bonding agents and processing aids. Vulcanization of rubber, types of vulcanisation, rheography, cure time, scorch time.
4.3 Polymer processing: Casting-die casting, rotational casting, film casting, thermoforming, foaming, lamination, reinforcing, processing of fibres-dry spinning, wet spinning, melt spinning, moulding processes-compression moulding, injection moulding, transfer moulding, blow moulding, extrusion moulding, calendaring
Unit 5: Fibre Science and Technology
5.1 Basic concepts, structural attributes of fibres, fibre characteristics.
5.2 Natural fibres: Natural fibres of vegetable origin, the seed and fruit fibres, natural fibres of animal origin-silk, natural mineral fibre.
5.3 Man-made fibres: Introduction, spinning, semi-synthetic fibres from cellulose, regenerated protein fibres, synthetic fibres-rayon, polyethylene terephthalate, nylon 6 and nylon 66, polyolefins, polyvinyl chloride, polyvinyl alcohol.
5.4 Miscellaneous fibres: Carbon fibre, glass fibre, boron fibre, ceramic fibre-alumina fibre.
5.5 Brief outline of manufacture of textiles: Fibres to yarn, yarns to fabrics-weaving, knitting, braiding, compound fabric constructions, finishing processes, dyeing and printing.
Unit 6: Rubber Manufacturing and Latex Technology
6.1 Natural rubber latex: Composition of latex, conservation, gelation, stability of latex & flocking, chemical modifications of natural latex- prevulcanisation, grafting, halogenations, hydro halogenations.
6.2 Synthetic latex: SBR lattices and its types like XSBR, properties, NBR lattices and its properties, poly chloroprene and its properties, butyl lattices, comparative study of natural, SBR, NBR & poly chloroprene.
6.3 Latex testing: Sampling, total solids, dry rubber content, pH, VFA number, KOH number, mechanical & chemical stability.
6.4 Manufacturing techniques: Dipping-principle & process, foam making-principle, dunlop process, talalay process.
6.5 Physical testing of rubber: Tests on raw materials, tests on rubber compounds, tests on vulcanised samples, tests on products.
6.6 Rubber product manufacturing machinery: Mixing mills, calender machine, extruder,

handfly screw press, hydraulic press.

Unit 7: Research Methodology of Chemistry
7.1 Purpose of research, conceptualization, elements of a research proposal, research project.
7.2 Types of research: Fundamental, applied and experimental research.
7.3 Chemical literature: Primary, secondary and tertiary sources of literature, literature databases-ScienceDirect, SciFinder, Chemical Abstract.
7.4 Scientific writing: Scientific document, writing of research paper, short communications, review articles, monographs, authored books, edited books and dissertation.
7.5 Important scientific and chemistry journals of various publishers and their impact factors.
7.6 Introduction to: subject index, substance index, author index, h-index.

ANALYTICAL CHEMISTRY

Unit 1: Instrumental Methods
1.1 Electrical and nonelectrical data domains-transducers and sensors, detectors, examples for piezoelectric, pyroelectric, photoelectric, pneumatic and thermal transducers. Criteria for selecting instrumental methods-precision, sensitivity, selectivity, and detection limits.
1.2 Signals and noise: sources of noise, S/N ratio, methods of enhancing S/N ratiohardware and software methods.
1.3 Electronics: transistors, FET, MOSFET, ICs, OPAMs. Application of OPAM in amplification and measurement of transducer signals.
1.4 UV-Vis spectroscopic instrumentation: types of optical instruments, components of optical instruments-sources, monochromators, detectors. Sample preparations. Instrumental noises. Applications in qualitative and quantitative analysis.
1.5 Molecular fluorescence and fluorometers: photoluminescence and concentration electron transition in photoluminescence, factors affecting fluorescence, instrumentation details. Fluorometric standards and reagents. Introduction to photoacoustic spectroscopy.
1.6 IR spectrometry: instrumentation designs-various types of sources, monochromators, sample cell considerations, different methods of sample preparations, detectors of IRNDIR instruments. FTIR instruments. Mid IR absorption spectrometry. Determination of path length. Application in qualitative and quantitative analysis.
1.7 Raman Spectrometric Instrumentation: sources, sample illumination systems. Application of Raman Spectroscopy in inorganic, organic, biological and quantitative analysis.
1.8 NMR Spectrometry-magnets, shim coils, sample spinning, sample probes (1H, 13C, 32P). Principle of MRI.
Unit 2: Sampling
2.1 The basis and procedure of sampling, sampling statistics, sampling and the physical state, crushing and grinding, the gross sampling, size of the gross sample, sampling liquids, gas and solids (metals and alloys), preparation of a laboratory sample, moisture in samples-essential and non-essential water, absorbed and occluded water, determination of water (direct and indirect methods).
2.2 Decomposition and dissolution, source of error, reagents for decomposition and

dissolution like HCl, H_2SO_4, HNO_3, $HClO_4$, HF, microwave decompositions,

combustion methods, use of fluxes like Na_2CO_3, Na_2O_2, KNO_3, NaOH, $K_2S_2O_7$,B_2O_3 and lithium metaborate. Elimination of interference from samples-separation by precipitation, electrolytic precipitation, extraction and ion exchange. Distribution ratio and completeness of multiple extractions. Types of extraction procedures.

Unit 3: Applied Analysis

3.1 Analytical procedures involved in environmental monitoring. Water quality-BOD, COD, DO, nitrite, nitrate, iron, fluoride.

3.2 Soil-moisture, salinity, colloids, cation and anion exchange capacity.

3.3 Air pollution monitoring sampling, collection of air pollutants-SO_2, NO_2, NH_3, O_3 and SPM.

3.4 Analysis of metals, alloys and minerals. Analysis of brass and steel. Analysis of limestone. Corrosion analysis.

Unit 4: Capillary Electrophoresis and Capillary Electro Chromatography

4.1 Capillary electrophoresis-migration rates and plate heights, instrumentation, sample introduction, detection(indirect)-fluorescence, absorbance, electrochemical, mass spectrometric, applications. Capillary gel electrophoresis. Capillary isotachophoresis. Isoelectric focusing.

4.2 Capillary electro chromatography-packed columns. Micellar electro kinetic chromatography.

Unit 5: Process instrumentation

5.1 Automatic and automated systems, flow injection systems, special requirements of process instruments, sampling problems, typical examples of C, H and N analysers.

Unit 6: Aquatic Resources

6.1 Aquatic resources: renewable and non-renewable resources, estimation, primary productivity and factors affecting it, regional variations.

6.2 Desalination: principles and applications of desalination-distillation, solar evaporation, freezing, electrodialysis, reverse osmosis, ion exchange and hydrate formation methods. Relative advantages and limitations. Scale formation and its prevention in distillation process.

6.3 Non-renewable resources: inorganic chemicals from the sea-extraction and recovery of chemicals, salt from solar evaporation.

MASTER THESIS