



SWAMI VIVEKANAND
SUBHARTI
UNIVERSITY
UGC Approved Meerut



Ordinance No. :- V-141-B-15

**(Approved in Academic Council meeting held on 11.03.2026
Proposed to be ratified in forthcoming executive council)**

**Evaluation Scheme and Syllabus
of**

M.Sc. POLYMER SCIENCE

TWO – YEAR POST GRADUATE

PROGRAM

(AS PER NEP-2020)

Keral Verma Subharti College of Science

Swami Vivekanand

SUBHARTI UNIVERSITY

Meerut

Effective from 2025-2026

K. V. Subharti College of Science
S. V. Subharti University
NH-58 Bypass Road, Meerut

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Abhishek

Yash

Pooja

Ravi

Programme Educational Objectives (PEO)

PEO 1: To deliver advanced concepts in Chemistry covering topics in Analytical, Inorganic, Organic and Physical Chemistry, while also reinforcing the fundamental concepts.

PEO2: To make students proficient in advanced laboratory techniques, enabling them to independently plan and conduct experiments as well as to work as a team.

PEO 3: To expose the students to a range of analytical methods using modern instrumentation, enabling them to analyze results at a higher level.

PEO 4: To become competent polymer scientists/engineers capable of applying fundamental and advanced concepts of polymer chemistry, materials science, and related technologies to solve industrial, research, and societal challenges.

PEO5: To engage in research, innovation, and lifelong learning to contribute to advancements in polymer synthesis, characterization, processing, and applications..

Programme Outcomes (PO's)

PO1: Attain sound knowledge about the fundamentals and applications of chemical and scientific theories.

PO2: Gain knowledge and understanding of reaction mechanisms, complex chemical structures, instrumental method of chemical analysis, molecular rearrangements and separation techniques.

PO3: Acquire general, technical, and professional skills to accomplish tasks in research, industry or academia.

PO4: Apply of knowledge and skills in addressing social economic and environmental problems.

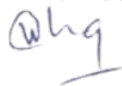
PO5: Apply knowledge of polymer chemistry, organic chemistry, physical chemistry, and materials science to understand and solve problems in polymer science.

PO6: Design and perform polymer synthesis using techniques such as free-radical polymerization, coordination polymerization, step-growth polymerization, and controlled/living polymerization.

PSO1 : Understand ethical issues related to polymer production, material safety, waste management, and environmental impact..

PSO2 : Recognize the need for continuous learning and keep pace with emerging technologies in advanced polymers, nanomaterials, and sustainable materials.

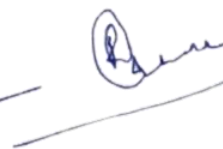
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CREDIT DISTRIBUTION TABLE

M.Sc. Polymer Science Program offered by Department of Chemistry (Session 2025-26 onwards)

		I	II	Internship after II Semester	III	IV	Total
1	Core Course	16	16	4	8	4	44
2	Elective (DEC)	-	-		8	8	16
3	PC/Dissertation/Project Work	8	8		8	12	36
4	SEMINAR/VAC/OEC/EEC/C HM	2 (SEMINAR)	2 (CHM)		2 (OEC)	2 (EEC)	8
	Total	26	26		26	26	108

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List of all Courses under different categories for M.Sc. Industrial Chemistry

Semester	Course Type	Course Code	Course Name	Credits
Semester I	Core Course -1	MSPS -101	Physical Chemistry - I	4
	Core Course -2	MSPS -102	Inorganic Chemistry - I	4
	Core Course -3	MSPS -103	Organic Chemistry - I	4
	Core Course -4	MSPS -104	Analytical Chemistry - I	4
	Practical Course -1	MSPS -105P	Qualitative & Quantitative Analysis of Inorganic Compounds	4
	Practical Course - 2	MSPS -106P	Physical Chemistry Laboratory	4
	SEMINAR	MSPS -107		4
Semester II	Core Course -5	MSPS -201	Physical Chemistry - II	4
	Core Course -6	MSPS -202	Inorganic Chemistry - II	4
	Core Course -7	MSPS -203	Organic Chemistry – II	4
	Core Course -8	MSPS -204	Analytical Chemistry - II	4
	Practical Course -3	MSPS -205P	Qualitative & Quantitative Analysis of Organic Compounds	4
	Practical Course - 4	MSPS -206P	Analytical Method Development and Validation	4
	CHM	CHM	Intellectual Property Rights	2
Semester III	Core Course - 9	MSPS -301	Polymer Chemistry	4
	Core Course - 10	MSPS -302	Plastic and Rubber Technology	4
	DISCIPLINE ELECTIVE COURSE -1	MSPS -303A/ MSPS -303B/ MSPS-303C/ MSPS -303D	Bioinorganic Chemistry / Bioorganic Chemistry/Biophysical Chemistry/Natural Products Chemistry	4
	DISCIPLINE ELECTIVE COURSE -2	MSPS -304A/ MSPS -304B/ MSPS -304C/ MSPS -304D	Nanochemistry / Organometallic Chemistry / Quantum Chemistry/ Surface Chemistry	4
	Practical Course -5	MSPS -305P	Polymer Science Laboratory -1	4

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	Practical Course -6	MSPS -306P	Polymer Science Laboratory -2	4
	OEC		To Be selected from the Bucket of Courses	2
Semester IV	Core Course - 11	MSPS - 401	Applied Polymer Science	4
	DISCIPLINE ELECTIVE COURSE - 3	MSPS -402A/ MSPS -402B/ MSPS -402C/ MSPS -402D	Green Chemistry/ Polymer Chemistry/ Material Chemistry/Computational Chemistry	4
	DISCIPLINE ELECTIVE COURSE - 4	MSPS -403A/ MSPS -403B/ MSPS-403C/ MSPS -403D	Medicinal Chemistry/ Environmental Chemistry/ Photochemistry/ Supramolecular Chemistry	4
	DISSERTATION	MSPS -404	Project	12
	EEC			2

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Program Name -M.Sc. Polymer Science													
Batch:2025-27				SEMESTER:I									
S. No.	Course Type	Course Code	Course Name	Teaching Load			Credits	Internal Assessment				External Assessment	Total
				L	T	P		CLASS PARTI CIPAT ION	Quiz/PPT/ Assignment (10)	Mid Sem Test (15)	TO TAL		
THEORY and PRACTICAL SUBJECTS							CLASS PARTI CIPAT ION	Quiz/PPT/ Assignment (10)	Mid Sem Test (15)	TO TAL	End Sem Exam (70)		
1	CORE COURSE-1	MSPS -101	Physical Chemistry-I	4	0	0	4	5	10	15	30	70	100
2	CORE COURSE-2	MSPS -102	Inorganic Chemistry-I	4	0	0	4	5	10	15	30	70	100
3	CORE COURSE-3	MSPS -103	Organic Chemistry-I	4	0	0	4	5	10	15	30	70	100
4	CORE COURSE-4	MSPS -104	Analytical Chemistry - I	4	0	0	4	5	10	15	30	70	100
5	PRAC TICAL COURSE-1	MSPS -105P	Qualitative & Quantitative Analysis of Inorganic Compounds	0	0	8	4	5	10	15	30	70	100
6	PRAC TICAL COURSE-2	MSPS -106P	Physical Chemistry Laboratory	0	0	8	4	5	10	15	30	70	100
7	SEMINAR	SEMINAR		0	0	4	2	4	4	7	15	35	50
TOTAL CREDITS / ASSESSMENT							26	34	64	97	195	455	650

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Batch:2025-27			SEMESTER:II										
S. No	Course Type	Course Code	Course Name	Teaching Load			Credits	Internal Assessment				External Assessment	Total
				L	T	P		CLASS PARTICIPATION	Quiz/PP T/Assignment (10)	Mid Sem Test (15)	TO TAL		
THEORY and PRACTICAL SUBJECTS								CLASS PARTICIPATION	Quiz/PP T/Assignment (10)	Mid Sem Test (15)	TO TAL	End Sem Exam (70)	
1	CORE COURSE-5	MS PS-201	Physical Chemistry-II	4	0	0	4	5	10	15	30	70	100
2	CORE COURSE-6	MS PS-202	Inorganic Chemistry-II	4	0	0	4	5	10	15	30	70	100
3	CORE COURSE-7	MS PS-203	Organic Chemistry-II	4	0	0	4	5	10	15	30	70	100
4	CORE COURSE-8	MS PS-204	Analytical Chemistry - II	4	0	0	4	5	10	15	30	70	100
5	PRACTICAL COURSE-3	MS PS-205 P	Qualitative & Quantitative Analysis of Organic Compounds	0	0	8	4	5	10	15	30	70	100
6	PRACTICAL COURSE-4	MS PS-206 P	Analytical Method Development and Validation	0	0	8	4	5	10	15	30	70	100
7	CHM	CHM	Intellectual Property Rights	2	0	0	2	4	4	7	15	35	50
TOTAL CREDITS / ASSESSMENT							26	34	64	97	195	455	650

1. AN INTERNSHIP COURSE OF 4 CREDITS OF 4-6 WEEKS DURATION DURING SUMMER VACATION, AFTER IIND SEMESTER TO BE COMPLETED BY EVERY STUDENT. INTERNSHIP CAN BE EITHER FOR ENHANCING THE EMPLOYABILITY OR AN DEVELOPING THE RESEARCH APTITUDE.
2. THE POST GRADUATE DIPLOMA IN CHEMISTRY WILL BE AWARDED HERE AFTER THE SUBMISSION OF INTERNSHIP COURSES OF 04 CREDITS.

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Semester I

Course Name: Physical Chemistry -I	Course Code: MSPS-101
Credit 4	Core Course -1

Course Objectives

1. To provide the understanding of physical states of matter and their practical applications. To define how the initially primitive models of real gases in physical chemistry are elaborated to take into account more detailed observations.
2. To understand the concept of partial molar quantities and their variation with temperature and pressure.
3. The concept of ensembles, partition function and their applications in studying gaseous molecules.
4. To understand the concept and different theories of ions and electrolyte interactions
5. To discuss the theoretical aspects of chemical kinetics and the importance of rate equations and different theories for studying the kinetics of complex reactions.
6. To provide an in-depth analysis of various phenomenon, laws and applications of States of Matter, Thermodynamics, Electrochemistry, Phase Equilibrium and Chemical Kinetics.

Course Outcomes

- CO1:** Understand the detailed concept of liquid and gaseous state and the structural features of solid state material by having complete knowledge of X-ray diffraction and its analysis.
- CO2:** Understand the application of second law of thermodynamics and the concept of third law of thermodynamics.
- CO3:** Familiarize with the applications of partition function and statistics in understanding the thermodynamics of molecules.
- CO4:** Understand the concept of electrical double layer at the electrode electrolyte interface by studying different proposed models of it.
- CO5:** Understand the detailed concepts of kinetics and its applications, Influence of physical and chemical parameters on reaction rates in solutions
- CO6:** Do the in-depth analysis of various phenomenon and laws of States of Matter, applications of Thermodynamics, Electrochemistry and Chemical Kinetics and different functions of statistical thermodynamics.

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Course Description

The course is framed to give broad view of states of matter, chemical potential, concepts of electrical double layer in solutions and various models to explain it. Concept of existence of different phases in the form of phase diagrams and their existence with changing variables.

Outline Syllabus

Unit 1 States of Matter

- (a) Gaseous State : Maxwell–Boltzmann distribution of molecular velocities of gases.
- (b) Liquid State: Structure of liquids, Radial distribution functions, Monte–Carlo method, Molecular dynamics.
- (c) Solid State: Types of solids, Debye- Scherrer method of X-ray structure analysis of crystals, indexing of reflections, structure of simple lattice and X-Ray intensities, structure factor and its relation to intensity and electron density, Rietveld analysis, particle size of crystallites.

Unit 2 Thermodynamics

Essentials of thermodynamics, fugacity, standard state of real gases, the relation between fugacity and pressure, Partial molar quantities, chemical potential and GibbsDuhem equation.

Classius – Clayperon equation; law of mass action and its thermodynamic derivation, variation of chemical potential with temperature and pressure, chemical potential for an ideal gas, determination of partial molar volume, thermodynamic functions of mixing (free energy, entropy, volume and enthalpy), third law of thermodynamics, residual entropy, meaning and scope of irreversible thermodynamics.

Unit 3 Statistical Thermodynamics

Concept of distribution, Thermodynamic probability and most probable distribution.Ensembles,

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Canonical, grand canonical and microcanonical ensembles.

Partition function - Translational, Rotational, Vibrational and Electronic partition functions, calculation of thermodynamic properties in terms of partition function. Applications of partition functions.

Heat capacity behaviour of solids - Chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law, Bose-Einstein statistics - distribution law, Evaluation of Lagrange's undetermined multipliers.

Unit 4 Electrochemistry

Debye-Huckel theory of ion- ion interactions, DebyeHuckel limiting law of activity coefficients and its limitations.

Debye - Huckel -Onsager treatment for aqueous solutions and its limitations, Wein effect, Debye – Falkenhagen effect.

The electrode-electrolyte interface: The electrical double layer -The Helmholtz-Perrin parallel plate model, the Gouy-Chapman diffuse-charge model and the Stern model, excess function.

Unit 5 Chemical Kinetics

Simple collision theory of reaction rates, Arrhenius equation and activated complex theory (ACT), thermodynamic treatment, chain reactions (hydrogenhalogen reactions) decomposition of N_2O_5 .

Theory of unimolecular reactions: Lindemann – Hinshelwood mechanism of unimolecular reactions, RRKM and Slater treatment.

Factors affecting rate of chemical reactions in solution Effect of solvent and ionic strength (Primary salt effect) on rate constants, secondary salt effect.

Reference Books

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1. Atkins P. W., Physical Chemistry, Oxford University Press, New York.
2. Kapoor K. L., Textbook of Physical Chemistry (Volume 1)
3. Kapoor K. L., Textbook of Physical Chemistry (Volume 3)
4. Kapoor K. L., Textbook of Physical Chemistry (Volume 5)
5. Puri, Sharma and Pathania, A Textbook of Physical Chemistry, Vishal Publishing Cor

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Semester I

Course Name: Inorganic Chemistry - I	Course Code: MSPS-102
Credit 4	Core Course -2

Course Objectives

- 1.To provide an insight into bonding and structure of coordination compounds.
- 2.To explain the spectral and magnetic behaviour of coordination compounds.
- 3.To provide a thorough knowledge about the chemistry and application of inner transition metals.
- 4.To discuss about various spectroscopic methods for structure elucidation of inorganic compounds.
- 5.To explain the basics of radioactivity as well as various radio analytical techniques.
- 6.To impart knowledge about structure, bonding and application of inorganic compounds and radio chemistry.

Course Outcomes

- CO1:** Explain the various theories of metal –ligand bonding.
- CO2:** Explain the electronic spectra and magnetic properties of transition metal complexes.
- CO3:** Interpret the EPR and Mossbauer spectra.
- CO4:** Illustrate the chemistry and uses of inner transition metals.
- CO5:** Know about various radio-analytical techniques.
- CO6:** Gain knowledge about of various aspects of modern inorganic chemistry.

Course Description

This course includes basic concepts of metal –ligand bonding, magnetic and electronic properties of coordination compounds and their characterization techniques. Chemistry of inner transition metals and nuclear chemistry are also discussed in this course.

Outline Syllabus

Unit 1 Metal-ligand Bonding

Overview of crystal field and ligand field theories of 4-, 5-and 6-coordinated complexes, d-orbitals splitting in linear, trigonal, octahedral, square planar, tetrahedral, square pyramidal, trigonal-bipyramidal and cubic complexes. Measurement of CFSE (d1 to d10) in weak and strong ligand fields, JahnTeller distortion,

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Molecular orbital theory (MOT) of coordination compounds: Composition of ligand group orbitals, molecular orbital energy diagrams of octahedral, tetrahedral, square planar complexes including both s and p bonding, angular overlap model.

Unit 2 Electronic Spectra and Magnetic Properties of Transition Metal Complexes

Interpretation of electronic spectra, Orgel diagrams, Tanabe-Sugano diagrams for transition metal complexes (d1 - d 9 states), calculations of Dq, B and β parameters.

Charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information.

Anomalous magnetic moments, magnetic exchange coupling, temperature independent paramagnetism (TIP) of complexes, spin cross over phenomenon. Effect of temperature on their magnetic properties.

Unit 3 Chemistry of Inner Transition Elements

General discussion on the properties of the f-block elements.

Redox, Spectral and Magnetic properties.

Use of Lanthanide compounds as shift reagents. Photophysical properties of Lanthanide complexes.

Unit 4 Characterization Techniques

EPR spectroscopy-basic principle, hyperfine and superhyperfine lines, anisotropy, g values, application in selected inorganic compounds.

Mossbauer Spectroscopy-Gamma ray emission and absorption by nuclei, Mossbauer effect -conditions, Doppler effect, instrumentation, chemical shift examples, quadrupole effect.

Use of Mössbauer spectra in chemical analysis, typical spectra of iron and tin compounds. Optical rotatory dispersion (ORD) and circular dichroism (CD).

Unit 5 Nuclear Chemistry

Nuclear structures and nuclear stability. Nuclear models; radioactivity and nuclear reactions. Detection and measurement of radiation. Tracer techniques.

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Study of chemical reactions, isotope exchange reactions, kinetic isotope effect, nuclear activation analyses, Principle of nuclear detection, gas detector, ionization chamber, proportional and G. M. detector.

Radioactive Techniques: Detection and measurement of radiation- GM ionization and proportional counters.

Radiometric analysis: Isotope dilution analysis, age determination, neutron activation analysis (NAA) and their applications. Radiation hazards and safety measures.

Reference Books

1. Inorganic Chemistry, J.E. Huhey, Harper & Row
2. Concise Inorganic Chemistry, J. D. Lee, Elbs with Chapman and Hall, London.
3. The Chemical bond, J.N. Murrel, SFA Kettle and J.M. Tedder, Wiley, New York.
4. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.

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Semester I

Course Name: Organic Chemistry - I	Course Code: MSPS-103
Credit 4	Core Course -3

Course Objectives

This course aims to

1. Analyze delocalized chemical bonding mechanisms, including resonance, hyperconjugation, aromaticity, and tautomerism.
2. Examine thermodynamic and kinetic requirements influencing reaction mechanisms and apply key concepts such as the Hammond postulate, Curtin-Hammett principle, and catalytic processes in organic reactions.
3. Differentiate between classical and non-classical carbocations and their rearrangements and explain the reactivity of carbanions, free radicals, carbenes, nitrenes, and benzyne.
4. Identify elements of symmetry and chirality in organic molecules and understand stereochemical concepts such as stereospecificity, stereoselectivity, and asymmetric synthesis.
5. Perform conformational analysis of cyclic systems and determine their effects on chemical reactivity. Also, evaluate stereochemical factors.

Course Outcomes

Upon successful completion of this course, students will be able to

CO1: Explain and apply delocalized bonding concepts (resonance, hyperconjugation, and tautomerism) in organic molecules and determine aromaticity in organic compounds using Huckel's rule and modern aromaticity principles.

CO2: Predict the reaction mechanism of organic transformations based on kinetic and thermodynamic considerations.

CO3: Identify and analyze key reaction intermediates (carbocations, carbanions, free radicals, carbenes, and benzyne) and their reactivity.

CO4: Apply stereochemical principles to understand molecular chirality, stereoselectivity, and asymmetric synthesis strategies.

CO5: Perform conformational analysis of cyclic systems and predict their impact on reaction outcomes, and evaluate the role of neighboring group participation in substitution and elimination reactions.

CO6: Gaining expertise in bonding, reaction mechanisms, intermediates, and stereochemistry, enabling them to analyze structures, predict reactivity, and apply concepts in research and industry.

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This course provides an in-depth exploration of advanced organic chemistry, focusing on bonding, reaction mechanisms, intermediates, and stereochemistry. It covers delocalized chemical bonding, aromaticity, and reaction pathways, emphasizing kinetic and thermodynamic principles. The study of key reaction intermediates such as carbocations, carbanions, and free radicals enhances the understanding of organic transformations. Stereochemical concepts, including chirality, conformational analysis, and asymmetric synthesis, are explored to predict molecular behavior in various reactions. Through theoretical and applied perspectives, this course equips students with the skills necessary for research and industrial applications in organic chemistry

Outline syllabus

Unit 1 Nature of Bonding in Organic Molecules

Delocalized chemical bonding: conjugation, cross conjugation, resonance, hyperconjugation, tautomerism;

Criteria for aromaticity: Huckel's $4n+2$ electron rule for benzenoid and nonbenzenoid aromatic compounds; Application in carbocyclic and heterocyclic systems, annulenes, heteroannulene, fullerenes, C-60, cryptates, azulenes.

Current concepts of aromaticity: Anti-aromatic, nonaromatic and homoaromatic compounds, Effect of tautomerism and hyperconjugation on aromaticity.

Unit 2 Reaction Mechanism - Structure and Reactivity

Types of reaction mechanisms: substitutions, eliminations, additions, rearrangements, thermodynamic and kinetic requirements.

Hammond postulate, Curtin-Hammett principle, transition states and intermediates, catalysis: electrophilic catalysis, acid and base catalysis.

Methods of determination of reaction mechanism methods: Detection of intermediates, Stereochemical and chemical evidences, Identification of products, isotopic labelling and cross-over experiments.

Unit 3 Reaction Intermediates

Carbocations: Classical and nonclassical, phenonium ions, norbornyl system, common carbocation rearrangement: Wagner Meerwein rearrangement, Demjonnev rearrangement, and Pinacol-pinacolone rearrangement.

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Carbanions: formation, stability and their reactions. HSAB principle and its applications.

Free radicals: formation, stability and reactions, cage effects, radical cations and radical anions;

Carbene: Synthesis, structure and reactions of singlet and triplet carbene, nitrenes, Benzynes.

Unit 4 Stereochemistry I

Elements of symmetry, chirality (centre, axis, and plane), molecules with more than one chiral center, threo and erythro isomers, optical purity.

Topicity of ligands and faces and their nomenclature, stereogenicity, chirogenicity and pseudosymmetry, stereospecific and stereoselective reactions.

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

Unit 5 Stereochemistry II

Conformational analysis of cyclic systems: Cyclohexane and its derivatives (mono- and di-substituted), fused (decalins) and bridged bicyclic systems.

Nucleophilic addition to carbonyl group: Cram, Franklin Ahn Model, Cieplak effect, Effect of conformation on the reduction of cyclic ketones, nucleophilic substitution on cyclohexane substrates, cyclohexane epoxide formation and opening.

Elimination reactions of cyclohexyl halides, de-amination of 2-aminocyclohexanols, elimination vs substitution competition and neighboring group participation reactions of acyclic and cyclic molecules.

Reference Books

1. Organic Chemistry, R. T. Morrison and R. N. Boyd, (1992) 6th Edition, Prentice-Hall.
2. Reaction Mechanism in Organic Chemistry, (1976) 1st Edition, S. M. Mukherji and S. P. Singh, Macmillan.
3. Stereochemistry, P. S. Kalsi, (1994), 2nd Edition, New Age International.

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Semester I

Course Name: Analytical Chemistry -I	Course Code: MSPS-104
Credit 4	Core Course -4

Course Objectives

1. Provide and enrich the students to analytical techniques, various types of errors knowingly/ unknowingly introduced, accuracy and confidence limit in analytical process.
2. Provide detailed insight of chemical equilibrium and its effect in chemical analysis of analyte.
3. Provide detailed technical knowledge of various chromatographic separation techniques based on physical state, contact and separation mechanism.
4. Provide detailed technical knowledge of gas, thin layer chromatographic, integrated LC-MS and GC-MS separation techniques for qualitative and quantitative analysis.
5. Enable the students to study the thermal behaviour of different compounds and study temperature dependent decomposition process and structural elucidation of unknown analyte.
6. Estimate the temperature dependent weight loss in compound and model and optimize suitable temperature condition for further chemical processing.

Course Outcomes

- CO1:** Apply the knowledge of analytical techniques to minimize the error and report the outcomes of analysis with high precision and accuracy.
- CO2:** Understand the role of different analytical techniques used for the separation of compounds present in very small quantity.
- CO3:** Understand the role of chemical equilibrium in chemical analysis.
- CO4:** Segregate and select the suitable indicator for measurement of pH,.

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CO5: Purify the various compounds for their further detailed structural elucidation and molecular mass analysis.

CO6: To learn analytical tools involving Chromatographic methods and thermo-analytical instruments of a lab for the identification of equilibrium process.

Course Description

Analytical chemistry I emphasizes on various factors as - types of errors, accuracy and precision in chemical analysis, concepts of chemical equilibrium and its effects on qualitative and quantitative estimation, Chromatographic separation and Thermal analysis.

Outline syllabus

Unit 1 Introduction to Analytical Chemistry

Scope & objectives of Analytical chemistry and chemical analysis, Classification of analytical methods. Errors in chemical analyses- Accuracy and precision.

Types of error-determinant, indeterminate and gross. Nature of random errors, statistical treatment of random errors, standard deviation of calculated results, reporting of calculated data.

Unit 2 Concept of Equilibrium

General treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases.

Activity and activity coefficient; Effect of electrolytes on chemical equilibria, Calculation of pH.

Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators.

Unit 3 Chromatographic Methods – I

General principle, classification of chromatographic methods based on physical state, contact and separation mechanism.

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Nature of partition forces. Chromatographic behavior of solutes. Chromatographic resolution, selectivity factor and column efficiency.

Column chromatography: Nature of column materials, Preparation of the column, Solvent systems, detection methods and applications.

Unit 4 Chromatographic Methods - II

Gas chromatography- principle, experimental technique, carrier gas, sample injection, column, detector and application.

High Performance Liquid Chromatography (HPLC): instrumentation- solvent and reservoirs, pumping system, sample injection, Column, detectors

Thin layer chromatography: coating of materials, preparation of TLC, Solvents, methods of detection and applications. Theory and application of LC-MS, Pyrolysis GC-MS, Thermal Desorption GC-MS.

Unit 5 Thermal Analysis

Principle, different methods of thermal analysis,

i) Thermo gravimetric methods of analysis(TG/DTG):

Instrumentation, thermogram and information from thermogram, factors affecting thermogram, applications

TGA for quantitative analysis (TG analysis of $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, dolomite ore, etc.)

Problems based TGA,

ii) Differential Thermal Analysis (DTA):

Instrumentation, general principles, differential thermogram, DTA and TG curve together, Applications (DTA analysis of mixture of polymers, DTA of $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$, DTA of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$).

iii) Differential Scanning Calorimetry (DSC):

Principle, Instrumentation, and Applications (DSC curve of polyethylene terephthalate, DSC curve for isothermal crystallization of polyethylene, DSC of phenacetin), thermometric titrations, Evolved gas analysis.

Reference Books

1. Analytical Chemistry- An Introduction, 7th Edition, D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Saunders College Publishing, Philadelphia, London.

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2. Modern Methods of Chemical Analysis, 2nd Edition, R. L. Pecsok, L. D. Shields, T. Cairns and L.C. McWilliam, John Wiley, New York.
3. Analytical Chemistry, 5th Edition, G. D. Christian, John Wiley & Sons, New York.
4. Analytical Chemistry: Principles, 2nd Edition, J. H. Kennedy, Saunders Holt, London.

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Semester I

Course Name: Qualitative & Quantitative Analysis of Inorganic Compounds	Course Code: MSPS-105P
Credit 4	Practical course -1

Course Objectives

1. To find the individual strengths of acids and salts via thermometric titrations, conductometric titrations, precipitation titrations and pH metric titrations.
2. Find the heat of neutralization using Calorimetry.
3. To calculate the dissociation tendency of the acids.
4. To construct the phase diagrams of binary and ternary systems.
5. To learn software handling for chemistry problems.

Course Outcomes

Students will be able to –

CO1: To imply various types of titrations for quantitative analysis.

CO2: Construct the phase change behaviour in graphical form.

CO3: To carry out conductometric and potentiometric titrations.

CO4: To find the acidity strength accurately.

CO5: Utilize computational tools for solving chemical problems.

CO6: To imply titrations, Calorimetry, computational and phase change phenomena towards appropriate quantitative and qualitative assessment of the physical process.

Outline syllabus

Quantitative Analysis – I

- To determine the concentration of two acids, HCl and ethanoic acid, by thermometric titration and use it to calculate the enthalpy change of neutralization.
- To study precipitation titration between KCl and AgNO₃ conductometrically and determine the strength of the given solution of AgNO₃.

Qualitative Analysis – II

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- 1. Qualitative test for carbohydrates.
- 2. Qualitative test for lipids.
- 3. Qualitative test for amino acid and proteins.

Quantitative/Qualitative Assessment – I

- To determine the strength of strong acid and weak acid conductometrically by titrating against standard NaOH solution.
- To determine the strength of H_3PO_4 by titration with standard NaOH using pH meter.

Quantitative/Qualitative Assessment –II

- To study the separation of dyes by thin layer chromatography (TLC).
- To determine the amount of BaCl_2 in a given solution by conductometric titrations.
- Study the conductometric titration of hydrochloric acid with sodium carbonate.

Preparation and characterization of the following inorganic compounds:

- (i) Tetramminecupric sulphate $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- (ii) Sodium cobaltinitrite, $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$
- (iii) Potassium chromioxalate, $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$.

Reference Books

1. O.P. Pandey, D.N. Bajpai, S.Giri, “ Practical Chemistry”, S. Chand & Co.
2. Vogel’s “Textbook of quantitative Analysis”, Pearson
3. Practical Organic Chemistry: Preparations and Quantitative Analysis” by Mann and Saunders
4. Natural Products: A Laboratory Guide” by Raphael Ikan

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Semester I

Course Name: Physical Chemistry Laboratory	Course Code: MSPS-106P
Credit 4	Practical course -2

Course Objectives

Understand and apply solvent extraction techniques for the quantitative analysis of bioactive compounds such as caffeine, carotenoids, and beta-carotene from natural sources.

Gain proficiency in spectroscopic methods like UV-Visible spectroscopy and FTIR for purity analysis and quantification of extracted compounds.

Acquire knowledge of flame photometry for the determination of alkali metals (Na^+ , K^+) in environmental samples and perform regression and calibration curve analyses.

Master quantitative Thin Layer Chromatography (TLC) and paper chromatography methods, including color separation, elution, and quantification by colorimetry.

Understand High-Performance Liquid Chromatography (HPLC) operation, including mobile phase and column selection, chromatogram interpretation, and quantitative and qualitative analysis using peak area and height.

Understand Thermogravimetric Analysis (TGA) for studying thermal decomposition of substances and quantitative determination of components in ores and hydrates.

Course Outcomes

At the end of course students should be able to

CO1: Define various terms involved in practical methods of analysis.

CO2: Explain the instrumentations of colorimeter, spectrophotometer, photofluorometer, TGA, HPLC, Flame-photometer, CV, etc.

CO3: Apply/select method / instrumental parameters for analysis of the given sample.

CO4: Explain / describe basic principles of chromatography and different instrumental methods of analysis. Able to handle instruments according to SOP.

CO5: Differentiate among the various analytical methods / techniques of chemical analysis and verify

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theoretical principle practically or apply theory to explain practical observations.

CO6: Maintain a proper record of analytical data in notebook.

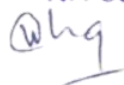
Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory.

Outline syllabus

Any 12 Experiments from the given list

1. Absorption spectra of organic compound.
2. To find out the surface tension of the given liquid by drop weight method at room temperature.
3. To determine the λ_{\max} of a given sample by visible spectrophotometer.
4. Determination of the concentration of unknown sample with the help of U.V visible spectrophotometer.
5. Solid Phase Extraction: Isolation of amino acids from aqueous sample using ion exchange resin and their identification by colorimetric test (very dilute glycine solution can be used as an example of alfa amino acid)
6. Pre-concentration using solid phase extraction on ion exchange cartridge and estimation. You can choose any metal ion which is present below detection limit. You will do preconcentration using ion exchange resin and will estimate by AAS or aqueous colorimetry (not solvent extraction). Example: Preconcentration of Cu(II) from brine (one can use aqueous solution of Cu(II) solution with less than 0.5 ppm conc.) and its estimation using R-Nitroso salt .
7. Flame photometric analysis of water /soil sample for Na^+ and K^+ by calibration curve method (give regression analysis for both curves) .
8. Determination of available chlorine from bleaching powder.
9. Determination of Ni^{2+} using DMG by Gravimetric method.
10. Selective estimation of SO_4^{2-} in presence of chloride from water sample or any other sample by calibration curve and its confirmation by turbidimetric titration method (give regression analysis for both curves).
11. Estimation of quinine sulphate from tablet by calibration curve and its confirmation by standard addition method.

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12. Separation of Colours by TLC / Paper chromatography, their isolation by elution from paper or TLC and quantification by colorimetry.

13. Analysis of the Composition of a Mixture of Nitroanilines by Thin-Layer Chromatography and Ultraviolet/Visible Spectrometry.

14. Demonstration Practical by Mentori. Handling of HPLC equipment, choice of mobile phase and column, sample preparation. ii. Record the chromatogram of pure substance and study

a) Effect of conc. on peak area and peak height

b) from retention time and length of column calculate number theoretical plates from.

c) Qualitative analysis – spiking method and by using retention time

d) Quantitative analysis by comparing peak height of sample with standard as well as by comparing peak area of sample with standard.

15. Demonstration Practical by Mentor Study of GC chromatogram: Record the TGA of pure NaHCO_3 (room temp to $300\text{ }^\circ\text{C}$). Explain different characteristics of thermogram and quantitative analysis by TGA. Explain how thermal decomposition reaction can be predicted from wt. loss.

16. TGA analysis of dolomite ore for CaCO_3 and MgCO_3 content.

17. Cyclic voltammetric study of Fe(II)/Fe(III) system. Basic principle and calculation of basic parameters from CV.

18. Construct graphite electrode using graphite rod from the dry pen-cell. Perform redox titration between Fe(II) and KMnO_4 using graphite electrode and calomel as reference electrode. Perform same titration using Pt electrode and calomel electrode. Report does Pt can be replaced by graphite or not. Give the reasons.

Reference Books

1. Vogel's Textbook of Quantitative Chemical Analysis, 6 th Ed

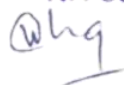
2. Indian Pharmacopeia, 2007

3. Chemical Separations Principle techniques and Experiments, Clifton E Meloan, Wiley Interscience.

4. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier

5. Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, Americal water works association, Water environment

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6. Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; New Age International Publishers
7. Extraction technique in Analytical Science, John R. Dean, Wiley
8. Experiments in modern analytical chemistry, D. Kealey, Springer Science Business media, 1986.
8. https://chem.libretexts.org/Courses/University_of_California_Davis/UCD_Chem_9_Lab_Manual/Lab_1%3A_Cyclic_Voltammetry
9. Cyclic Voltammetry Experiment James J. Van Benschoten. Jane Y. Lewis, and William R. Heineman, Journal of Chemical Education, Volume 60, Number 9, September 1983 (772-776) and Volume 60 Number 9 September 1983 (702-706)
11. Analysis of Soft Drinks: UV Spectrophotometry, Liquid Chromatography, and Capillary Electrophoresis, Journal of Chemical Education, Vol. 75 No. 5 May 1998
12. Analytical Chemistry for Technicians, John Kenkel, Third Edition, CRC Press LLC, 2003.

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Semester II

Course Name: Physical Chemistry - II	Course Code: MSPS-201
Credit 4	Core Course -5

Course Objectives

1. To familiarise students with theoretical and mathematical aspects of quantised energy levels of particle in box,
2. To introduce the theoretical concept of Hydrogen atom and hydrogen molecule and hydrogen molecule ion.
3. To infer the concept of Charge on colloids, electro kinetic phenomenon's and different theories on colloids.
4. To prioritise the surface phenomenon's and different equations and theories to explain them.
5. To describe equilibrium processes of one and more than one component systems such as congruent, Peritectic and Monotectic Systems.

Course Outcomes

CO1:The concepts of quantum mechanics and its mathematical interpretation for atoms and molecules possessing single electron.

CO2:The results and their analysis obtained on the basis of MOT and VBT for hydrogen atom, molecule and ion.

CO3:The nomenclature of particles on the basis of particle size and different theories and results related to stability of colloids.

CO4:The concept of surface tension, micellization and solubilisation.

CO5: The concept of existence of different phases with change in different variables by visualizing the phase diagrams

CO6: The concept of quantum mechanics, their application to MOT and VBT, how to draw phase diagrams and importance of colloids and surface chemistry in daily life, their concepts, phenomenon and mathematical equations.

Course Description

Concept of Quantum mechanics and its applications in MOT and VBT were shared with students. Theories of colloids and concepts of surface chemistry were discussed. The phase diagram of different component systems were discussed and explained how to plot them

Outline syllabus

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Unit 1 Quantum Mechanics

Matter waves, The Uncertainty principle, the wave nature of the electron, Postulates of Quantum Mechanics, Commutation of operators, Eigen value and Eigen function. Angular momentum operator, Ladder operator. The wave equation, Particle in one dimensional box, particle in three-dimensional box, Degeneracy.

Hydrogen atom: Schrodinger wave equation, Transformation of coordinates, separation of variable in polar spherical coordinates and its solution, probability distribution function, radial distribution function.

Unit 2 Chemical Bonding

Born Oppenheimer Approximation, The variation method, Ground state energy of the hydrogen atom. Huckel molecular orbital theory of conjugated systems, Secular equations, delocalisation energy, MOT and Valence bond theory- Hydrogen molecule.

Unit 3 Colloids

Introduction, Origin of the charges, electro-kinetic phenomena : electrophoresis, electro osmosis, sedimentation and streaming potential.

The concept of electrical double layer and various models to explain its structure and properties, DLVO theory and stability of colloids. Smoluchowski theory of kinetics of coagulation and distribution of colloids aggregates.

Unit 4 Surface Chemistry and Micelles

Surface tension and surface free energy; Pressure across an interface: Laplace equation, Kelvin equation.

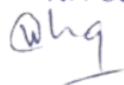
Adsorption in liquid systems: Gibbs adsorption isotherm; Adsorption on solids: Langmuir isotherm, BET isotherm. Micelles-Surface active agents, micellization, hydrophobic interaction, critical micellar concentration (cmc), factors affecting cmc of surfactants, micro emulsions, reverse micelles.

Unit 5 Phase Equilibria

Statement and meaning of the terms in Gibbs phase rule; phase equilibria of water, Helium and Carbon systems; Two component solid-liquid equilibria (example of Cu-Ni alloy, Bi - Cd system and CuSO₄ – H₂O System): simple eutectic; congruent melting type; peritectic type and monotectic type phase diagrams, concept of Phase equilibria of three component systems.

Reference Books:

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1. Atkins P. W., Physical Chemistry, Oxford University Press, New York.
2. Levine I. N., Physical Chemistry, Tata McGraw Hill Pub. Co. Ltd., New Delhi.
3. Adamson A. W., Physical Chemistry of Surfaces, John Wiley and Sons. Other References 1. Day M. C. and Selbin J., Theoretical Inorganic Chemistry. 2. Pashley R. M. and Karaman M. E., Applied Colloid and Surface Chemistry, Wiley Publications.
4. Singh N. B., Gajbhiye N. S. and Das S. S. Comprehensive Physical Chemistry, New Age publishers, New Delhi.
5. McQuarrie D. A. and Simon J. D., Physical Chemistry.

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Semester II

Course Name: Inorganic Chemistry - II	Course Code: MSPS-202
Credit 4	Core Course -6

Course Objectives

- 1.To introduce the basics concept of molecular symmetry and group theory.
- 2.To demonstrate the various application of group theory in spectroscopy.
- 3.To provide an introduction to basic concepts of Organometallic chemistry.
- 4.To explain to the student the various application of Organometallic chemistry in industry.
- 5.To provide information various industrially important Organometallic compounds.
- 6.To provide structure, bonding and reactivity of transition metal carbonyls, nitrosyls and phosphine complexes.

Course Outcomes

CO1: Understand the various basics concept of molecular symmetry and group theory.

CO2: Apply their knowledge of group theory to understand the principles of spectroscopy.

CO3: Know the basic concepts of organometallic chemistry and its application in industry.

CO4: Explain the structure and reactivity of transition metal alkyl, aryl, alkene, alkynes, allyls, dienyl and arene and carbene complexes.

CO5: Gain insight about transition metal carbonyls, nitrosyls and phosphine complexes.

CO6: Gain knowledge about advanced topics like organometallic chemistry and group theory.

Course Description

The course includes the basic concept of group theory and its application in chemistry; as well as organometallic chemistry of transition metals.

Outline syllabus

Unit 1 Molecular symmetry

Introduction, Meaning and examples of different symmetry elements and generated operations; and general rules, Derivation of matrices for rotation; reflection; rotation; reflection and inversion operations.

Symmetry operations of all the molecular point groups (C_n , D_n , C_{nh} , D_{nh} , C_{nv} , D_{nd} , S_n , T , T_d and T_h).

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Determination of the classes of operations by similarity transform method (only C_{2v} , C_{2h} , C_{3v}) and general rules Defining properties of 'group'; Types of groups, Subgroups; reducible and irreducible representations.

Unit 2 Application of Group Theory

Construction of character table for C_{2v} and C_{3v} point groups.

Optical activity and dipole moment of molecules.

Applications of group theory to electronic and vibrational spectroscopy.

Unit 3 Organometallic Chemistry-I

General Characteristics of organometallic compounds, Ligand hapticity, electron count for different types of organometallic compounds, 16 and 18 electron rule and exceptions, Fluxionality in organometallic complexes.

Synthesis, structure and bonding of organolithium compounds.

Organometallic reagents in homogeneous catalytic reactions (Hydrogenation, hydroformylation, isomerisation, polymerisation).

Unit 4 Organometallic Chemistry-II

General synthetic routes, nature of bond and structural characteristics of alkyl, aryl, alkene alkynes complexes of transition metals.

Structure and bonding of metallocenes.

Synthesis, structure and reactivity of metal carbene and carbynes

Unit 5 Organometallic Chemistry-III

Ligand behavior of CO, General methods of preparation, structures, bonding, and vibrational spectra of metal (Fe, Ru, Os, Cr, Ni) carbonyls.

Ligand behavior of NO (NO^+ , NO and bridging NO), preparation, structures, bonding of nitrosyls of Cr, Fe and Ru.

Preparation, structure, bonding and reactivity of metal phosphines. Comparison of phosphine and carbonyl ligands in terms of bonding.

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Reference Books:

1. Inorganic Chemistry, J.E. Huhey, Harper & Row.
2. Organometallic Chemistry, R.C.Mehrotra and A.Singh, New Age International. Other References
3. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley
4. Introduction to Ligand fields, B.N. Figgis, Wiley, New York.
5. The Organometallic Chemistry of the Transit ion Metals, R.H. Crabtree, John Wiley.
6. Transition metal chemistry, Fundamental concept and applications, A.Yamamoto, John Wiley, 1986.

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Semester II

Course Name: Organic Chemistry - II	Course Code: MSPS-203
Credit 4	Core Course -7

Course Objectives

This course aims to:

1. Develop an in-depth understanding of single bond (C- C) formation strategies and explore the role of enolates, enamines, and organometallic reagents in organic synthesis.
2. Develop the critical thinking to analyze the conditions required for C=C bond formation
3. Introduce metal-catalyzed carbon- carbon bond formation techniques and their applications.
4. Examine oxidation and reduction reactions, including stereochemical aspects and selectivity.
5. Analyze key name reactions and molecular rearrangements in organic synthesis

Course Outcomes

By the end of the course, students will be able to:

CO1: Utilize enolates, enamines, and organometallic reagents and metal-catalyzed coupling reactions for C- C bond formation.

CO2: Differentiate between elimination strategies for double bond formation and apply them effectively.

CO3: Implement oxidation techniques in organic synthesis with a focus on selectivity.

CO4: Understand the functional mode of various reducing reagents

CO5: Understand and predict the mechanisms of key organic name reactions and rearrangements.

CO6: Design synthetic routes using advanced organic transformations for target molecules

Course Description

This course provides a comprehensive understanding of modern organic synthesis, focusing on carbon-carbon (C-C) and carbon-carbon double bond (C=C) formation strategies. It covers the chemistry of enolates, enamines, and organometallic reagents, along with metal-catalyzed coupling reactions such as Suzuki, Heck, and Sonogashira. Key oxidation and reduction methodologies, including stereoselective transformations, are explored in detail. Additionally, the course examines important name reactions and molecular rearrangements, emphasizing their mechanisms and applications in organic synthesis. By integrating theoretical knowledge with practical applications, this course prepares students for advanced research and industrial challenges in organic chemistry.

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Unit 1 Aliphatic Nucleophilic Substitution

The SN₂, SN₁, mixed SN₁ and SET mechanism. The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and non classical carbocations,

Phenonium ions, nonbornyl system, Common carbocations rearrangements. The S_Ni mechanism, Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium.

Unit 2 Double bond (C=C) formations

Elimination reactions: Hoffmann vs. Saytzev's rule, Cope elimination, Phosphorus, nitrogen and sulfur ylides, Wittig reaction, Wittig-Horner reaction.

Mechanistic and stereochemical aspects of addition reactions involving electrophiles nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction.

Addition of Grignard reagents, Wittig reaction Mechanism of condensation reactions involving enolates—Aldol. Knoevenagel, Claisen, Mannich, Benzoin, Perkin reactions.

Unit 3 Aromatic Electrophilic Substitution

The arenium ion mechanism. orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeier reaction Gattermann-Koch reaction. Aromatic Nucleophilic Substitution The S_NAr. SN₁ benzene and SRN 1 mechanisms. Reactivity - effect of substrate structure. leaving group and attacking nucleophile. The von Richter. Sommelet-Hauser and Smiles rearrangements.

Unit 4 Oxidation and Reduction

Alkene oxidation: alkenes to carbonyls with bond cleavage, alkenes to alcohols/carbonyls without bond cleavage (Wacker oxidation).

Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification.

Oxidation of Alcohols: alcohols to carbonyls, alcohols to acids or esters, phenols (Fremy's salt), Swern

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oxidation.

Catalytic reduction (Pt, Pd, Ni), Dissolving metal reductions (alkali metals in Liq. NH₃ and Zn, Sn).

Reduction by hydride transfer reagents (Complex hydrides of Li and Na); Stereoselectivity of reduction with small hydride donors.

Reduction with non-metals: HI, Diimides and hydrazine.

Unit 5 Name Reactions and Molecular Rearrangements

A Hoffmann, Lossen, Curtius, Schmidt rearrangement

Mechanism of Baeyer Villiger, Favorskii rearrangement, Sommelet-Hauser rearrangement

Baylis-Hillman reaction, Henry reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction, Ugi reaction.

Reference Books

1. Organic Reactions and Mechanisms, P.S. Kalsi, (2002) 2nd Edition, New Age International Publishers.
2. Organic Chemistry, R. T. Morrison and R. N. Boyd, (1992) 6th Edition, Prentice-Hall.
3. Reaction Mechanism in Organic Chemistry, (1976) 1 st Edition, S. M. Mukherji and S. P. Singh, Macmillan.
4. Advanced Organic Chemistry Reactions: Mechanism and Structure, Jerry March, (1992) 4th Edition, John Wiley.
5. Organic Chemistry, Francis A. Carey, (1996) 3rd Edition, The McGraw-Hill Companies, Inc.
6. Modern Methods of Organic Synthesis South Asia Edition W. Carruthers, Iain Coldham, (2004) 4th Edition, Cambridge University Press 4. Principles of Organic Synthesis, R.O.C. Norman, (1978) 2nd Edition, Chapman and Hall.

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Semester II

Course Name: Analytical Chemistry II	Course Code: MSPS-204
Credit 4	Core Course -8

Course Objectives

1. Understand the theories and principles of qualitative and quantitative analysis through optical and spectroscopic technique.
2. Analyse the textural information of bulk materials and particle dimension.
3. Carry out qualitative and quantitative analysis employing descriptive knowledge of electrochemistry and electrochemical titration.
4. Separate and estimate macromolecule (proteins, enzymes, blood and natural products) electroanalytically.
5. Effectively use various sensors for estimation and gain idea about developing technologically potent sensor materials.
6. To learn the advance spectroscopic and microscopic methods for the analysis of molecular materials.

Course Outcomes

- CO1:** Understand various optical and spectroscopic methods for qualitative and quantitative analysis of metals and non- metal to trace level.
- CO2:** Evaluate the properties of materials such as porosity, density and microstructure of materials.
- CO3:** Develop new synthetic routes involving electrochemical redox process.
- CO4:** Understand principles of Cyclic Voltammetry and Electrophoresis.
- CO5:** Develop quick, sensitive and selective sensory materials for qualitative and quantitative estimation of analyte.
- CO6:** Investigate the molecular materials using advanced spectroscopic and microscopic techniques.

Course Description

Analytical chemistry II emphasizes on various parts of analytical methods as - Atomic Spectroscopy comprises of AAS, AES and ICPMS, Electron Microscopic techniques comprises of SEM, TEM and FESEM, Polarography and amperometry, Cyclic voltammetry and electrophoresis Chemical sensors.

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Unit 1 Atomic Spectroscopy

Theory, sources, burners, atomic emission spectra, atomic absorption spectra, effect of temperature on emission and absorption, Instrumentation for AES and AAS, standard addition and internal standard method of analysis
Comparison of atomic absorption and emission methods, Applications of AAS and AES Features of atomic mass spectroscopy, Atomic weight in mass spectroscopy, mass to charge ratio
Types of atomic mass spectroscopy, quadruple mass analyzer, time of flight mass analyzer, Inductively coupled mass spectroscopy (ICPMS), Instrumentation for ICPMS, Applications of ICPMS.

Unit 2 Electron Microscopic Techniques

Basic principle, instrumentation and application of Transmission Electron Microscope (TEM) and HRTEM
Basic principle, instrumentation and application of Scanning Electron Microscope (SEM)
Basic principle, instrumentation and application of FESEM

Unit 3 Electroanalytical Technique - I

Polarography Introduction, Instrumentation, Ilkovic equation and its verification
Derivation of wave equation, Determination of half wave potential, qualitative and quantitative applications
Amperometry: Basic principles, instrumentation, nature of titration curves and analytical principles

Unit 4 Electroanalytical Technique- II

Cyclic Voltammetry Cell design, instrumentation, current-potential relation for linear sweep voltammetry (LSV), cyclic voltammetry, interpretation of voltammograms.
Electrophoresis: Separation by adsorption-Affinity techniques, affinity elution from ion exchangers and other adsorbents.
Pseudo affinity adsorbents, polyacrylamide gel electrophoresis, isoelectric focusing, isotachopheresis

Unit 5 Chemical Sensors

A Principles, types of chemical sensors based on the modes of transductions, Types of chemical sensor based on the chemically sensitive materials
Solid electrolyte, gas, semiconductor, Humidity sensors, Biosensors sensors.
Electrochemical sensors (Potentiometric sensors, Ionselective electrodes, Membrane electrodes, Amperometric sensors).

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Reference Books:

1. Principles of Instrumental Analysis, Skkog, Holler, Nieman, (Sixth Ed.) Other References 1)
2. Introduction to Instrumental Analysis by R. D. Broun, McGraw Hill (1987)
3. Instrumental methods of chemical analysis by H. willard, L.Meritt, J.A. Dean and F.A. settle. Sixth edition CBS (1986)
4. Fundamentals of Analytical Chemistry, 6th edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing.
5. Principles of Instrumental Analysis, Skkog, Holler, Nieman, (Sixth Ed.)
6. Introduction to instrumental analysis by R. D. Braun, MC. GrawHillInternational edition.

Semester II

Course Name: Qualitative & Quantitative Analysis of Organic Compounds	Course Code: MSPS-205P
Credit 4	Practical Course -3

Outline syllabus

Part A

1. Isolation and identification of multi-functional compounds in a mixture of two organic compounds.
2. Identification of three acidic and basic radicals in the given mixture (sample 1)
3. Identification of three acidic and basic radicals in the given mixture (sample 2)
4. Application of spectral data (IR, UV, NMR and mass) for structural elucidation
5. Isolation of natural products:
 - i) Isolation of caffeine from tea leaves
 - ii) Isolation of piperene from black pepper
 - iii) Isolation of β -carotene from carrots
 - iv) Isolation of lycopene from tomatoes
 - v) Isolation of limonene from lemon peel
 - vi) Isolation of Eugenol from cloves

Part B

6. Quantitative analysis:
 - i) Estimation of glucose by chemical methods
 - ii) Estimation of amino acids by chemical methods
 - iii) Estimation of nitro group in organic compounds

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- iv) Estimation of iodine number by Vij's solution
- v) Estimation of protein, caffeine and glucose by UV/VIS spectra (quantitative analysis also)
- vi) Estimation of ascorbic acid by chemical/UV methods

7. Advanced organic synthesis: Multistage synthesis including photochemical methods; representative examples:

- i) Benzophenone → benzopinacol → benzopinacolone
- ii) Benzoin → benzil → benzilic acid
- iii) Benzaldehyde → chalcone → chalcone epoxide
- iv) Chalcone → chalconedibromide → α-bromochalcone
- v) Cyclohexanone → cyclohexanoneoxime → caprolactone

Reference Books:

1. Vogel's Textbook of Practical Organic Chemistry" by B.S. Furniss et
2. Systematic Qualitative Organic Analysis" by H.T. Clarke
3. Spectrometric Identification of Organic Compounds" by Robert M. Silverstein, Francis X. Webster, David J. Kiemle
4. Practical Organic Chemistry: Preparations and Quantitative Analysis" by Mann and Saunders
5. Natural Products: A Laboratory Guide" by Raphael Ikan

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Semester II

Course Name: Analytical Method Development and Validation	Course Code: MSPS-206P
Credit 4	Practical course - 4

Course Outcomes

At the end of course students should be able to

1. Define / understand various chemical terms involved Method development and validation.
2. Explain statistical parameters of Method development.
3. Apply / select particular method / instrumental parameters for analysis of given sample and give mathematical treatment to analytical data and able to interpret the results accurately.
4. Analyze the results able to take the decision regarding quality of sample.
5. Maintain proper record of analytical data in notebook.
6. Design / modify and validate new analytical method for chemical analysis of particular sample.

Outline syllabus

1. **Table Work:** a) Explain with example of each Accuracy, precision, noise level, detection limit, quantitation limit, b) Explain with example: Expression of results: Calculation of mean, standard deviation, error and absolute error, significant figure; Propagation of errors c) Explain with example: Calibration curve and standard addition method, Regression analysis of calibration curve and its importance.

Calculations using EXCEL: mean, standard deviation, plotting calibration curve and equation of line, regression, axis labelling, etc.

2. Determination of Alkalinity of Natural Waters.

3. Determination of Hardness in a Water Sample

4 Analytical method development and validation Study of visible spectroscopic or colorimetric method for estimation of particular metal ion:

a) Determination of best pH for colour formation reaction, and determination of λ_{\max} for quantitative analysis using limited conc. of metal ion and large excess ligand;

b) Determination of metal ligand ratio at best pH. B) Detection of possible interfering metal ion (such as Ca(II),

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Mg(II), Mn(II), Ni(II), Co(II), Cu(II), Fe(II)).

5. Estimation of Glucose – Glucose in different samples can be analysed by

- titration with Fehling solution
- Colorimetry Folin-Wu method or DNSA method
- Colorimetry-Glucose by oxidase peroxidase method and
- Polarimetry.

Samples are –

- glucose in saline (DNS),
- glucose in glucose supplement
- glucose in food. Mentor will assign any one sample to the student. Student have to choice suitable method for analysis of glucose in sample with reason. After discussion with mentor analyse the sample by particular method. .

6. Perform pH metric titration for estimation of CH_3COOH from vinegar using i) 0.1 M standardized NaOH using phenolphthalein indicator ii) 0.5 M standardized NaOH using pH meter. Compare the results of two methods and give your comment.

7. Determine Paracetamol in tablet conventional titration (redox titration with Ceric ammonium nitrate) and by potentiometric titration (redox titration using Pt and Calomel electrode) and compare the results of two method.

8. Benedict's test to determine the presence of reducing sugar.

9. Fehling's test to determine the presence of reducing sugar.

10. Iodine test to distinguish starch from other polysaccharides.

11. Molisch's test for detection of Monosacchrides.

Reference Books:

- Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier
- Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, Americal water works association, Water environment federation.
- Vogels textbook of Inorganic Quantitative Analysis, 6 th Ed, Pearson
- Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; New Age International Publishers

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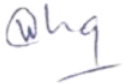
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5. Indian Pharmacopeia: 2007, Vol-1, 2, 3.
6. Chemical Analysis and Material Characterization by spectrophotometry, Bhim Prasad Kafle, Elsevier
- 7.. Ultraviolet and Visible Spectrophotometry in Pharmaceutical Analysis, SandorGorog, Published by CRC press, Taylor and Fransis.
8. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill publishing Company Ltd.
9. Manual Of Methods Of Analysis Of Foods Food Safety And Standards Authority Of India Ministry Of Health And Family Welfare Government Of India New Delhi 2015
10. Food Analysis, Edited by S. Suzanne Nielsen, Fourth Edition, Springer.

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Semester II

Course Name: Intellectual Property Rights	Course Code: CHM
Credit 2	

Unit I Overview of Intellectual Property

Introduction and the need for intellectual property right (IPR). IPR in India – Genesis and Development IPR in abroad. Some important examples of IPR.

Unit II Patents

Macro economic impact of the patent system. Patent and kind of inventions protected by a patent. Patent document. Protection of inventions. Granting of patent. Rights of a patent. Patent protection. Protection of inventions by patents. Searching, Drafting and Filing of a patent. The different layers of the international patent system (national, regional and international options).

Unit III: Patents: Utility models

Differences between a utility model and a patent. Trade secrets and know-how agreements.

Copyright: Introduction, How to obtain, Differences from Patents. Related rights. Distinction between related rights and copyright. Rights covered by copyright.

Unit IV Trademarks

Trademark, Rights of trademark. Kind of signs used as trademarks. Types of trademark. Function does a trademark perform. Protection and registration of trademark. Duration of trademark protection. Well-known marks and their protection. Domain name and it relate to trademarks.

Unit V Industrial Designs

Industrial design. Protection of industrial designs. Kind of protection is

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provided by industrial designs. Duration of protection.

IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies

– Police, Customs etc. Intellectual Property in the Indian Context – Various laws in India

Licensing and technology transfer.

Reference Books

1. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India Ltd, 2006

2. B.L. Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000

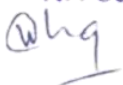
3. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi , 2010

4. N.K. Acharya: Textbook on intellectual property rights, Asia Law House (2001).

5. Manjula Guru & M.B. Rao, Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003).

6. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).

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Course Name -M. Sc. Polymer Science													
Batch:2025-27			SEMESTER:III										
S.No.	Course Type	Course Code	Course Name	Teaching Load			Credits	Internal Assessment				External Assessment	Total
				L	T	P		CLASS PARTI CIPATION	Quiz/PPT/Assignment (10)	Mid Sem Test (15)	TOTAL		
THEORY and PRACTICAL SUBJECTS								CLASS PARTI CIPATION	Quiz/PPT/Assignment (10)	Mid Sem Test (15)	TOTAL	End Sem Exam (70)	
1	CORE COURSE E-9	MSPS-301	Polymer Chemistry	4	0	0	4	5	10	15	30	70	100
2	CORE COURSE E-10	MSPS-302	Plastic and Rubber Technology	4	0	0	4	5	10	15	30	70	100
3	DISCIPLINE ELECTIVE COURSE E -1	MSPS-303A/M SPS-303B/M SPS-303C/M SPS-303D	Bioinorganic Chemistry/Bioorganic Chemistry/Bio physical Chemistry/Natural Products Chemistry	4	0	0	4	5	10	15	30	70	100
4	DISCIPLINE ELECTIVE COURSE E -2	MSPS-304A/M SPS-304B/M SPS-304C/M SPS-304D	Nanochemistry / Organometallic Chemistry/ Quantum Chemistry/ Surface Chemistry	4	0	0	4	5	10	15	30	70	100
5	PRACTICAL COURSE E-5	MSPS-305P	Polymer Science Laboratory -1	0	0	8	4	5	10	15	30	70	100
6	PRACTICAL COURSE E-6	MSPS-306P	Polymer Science Laboratory -2	0	0	8	4	5	10	15	30	70	100
7	OEC		To Be selected from the Bucket of Courses	2	0	0	2	4	4	7	15	35	50
TOTAL CREDITS / ASSESSMENT							26	34	64	97	195	455	650

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Course Name -M.Sc. Polymer Science													
Batch:2025-27				SEMESTER:IV									
S. No.	Course Type	Course Code	Course Name	Teaching Load			Credits	Internal Assessment			External Assessment	Total	
				L	T	P		CLASS PARTICIPATION	Quiz/PPT/Assignment (10)	Mid Sem Test (15)			TOTAL
THEORY and PRACTICAL SUBJECTS								CLASS PARTICIPATION	Quiz/PPT/Assignment (10)	Mid Sem Test (15)	TOTAL	End Sem Exam (70)	
1	CORE COURSE-11	MSPS-401	Applied Polymer Science	4	0	0	4	5	10	15	30	70	100
3	DISCIPLINE ELECTIVE COURSE - 3	MSPS-402A/M SPS-402B/M SPS-402C/M SPS-402D	Green Chemistry/ Polymer Chemistry/ Material Chemistry/Computational Chemistry	4	0	0	4	5	10	15	30	70	100
4	DISCIPLINE ELECTIVE COURSE - 4	MSPS-403A/M SPS-403B/M SPS-403C/M SPS-403D	Medicinal Chemistry/ Environmental Chemistry/ Photochemistry/ Supramolecular Chemistry	4	0	0	4	5	10	15	30	70	100
5	DISSERTATION	MSPS-404	Project	4	0	8	12	20	30	50	100	200	300
7	EEC			0	0	0	2	4	4	7	15	35	50
TOTAL CREDITS / ASSESSMENT							26	39	64	102	205	445	650

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Course Name -M.Sc. Polymer Science													
Batch:2025-27				SEMESTER:IV									
S.No.	Course Type	Course Code	Course Name	Teaching Load			Credits	Internal Assessment			External Assessment	Total	Remark
				L	T	P		CLASS PARTICIPATION	Quiz/PPT/Assignment (10)	Mid Sem Test (15)			
THEORY and PRACTICAL SUBJECTS								CLASS PARTICIPATION	Quiz/PPT/Assignment (10)	Mid Sem Test (15)	TOTAL	End Sem Exam (70)	
1	DISSERTATION	PC-1	Project	4	0	8	26	20				650	

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TOTAL CREDITS / ASSESSMENT								
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Semester - III

Course Name: Polymer Chemistry	Course Code: MSPS-301
Credit 4	Core Course -9

Course Objectives

1. Introduce the basic concepts of polymer chemistry, including classification, molecular weight, and thermal transitions.
2. Develop an understanding of mechanisms and kinetics of vinyl (addition) polymerization—free radical and ionic.
3. Provide knowledge on special polymerization techniques such as coordination, ring-opening, and step-growth polymerizations.
4. Explain industrial polymerization processes including bulk, solution, suspension, and emulsion techniques.
5. Familiarize students with polymer technology topics such as compounding, processing techniques, degradation, and applications.

Course Outcomes

CO1: To impart the knowledge of basics, classification, techniques of polymerization,

CO2: Students will be expected to gain knowledge basic concept of molecular weight determination and processing of polymers.

CO3: To understands the importance of different polymer process.

CO4: Explain mechanisms of polymerization, molecular weight determination, polymer characterization techniques, and structure–property relationships.

Course Description

This course provides an in-depth understanding of the chemistry of polymers, covering polymer fundamentals, classification, nomenclature, molecular weight determination, and thermal properties. Students learn mechanisms and kinetics of major polymerization processes including free-radical, ionic, coordination, ring-opening, and step-growth polymerizations. The course also explores polymerization techniques (bulk, solution, suspension, emulsion) and polymer processing methods such as compounding, injection molding, and extrusion. Emphasis is placed on linking polymer structure, synthesis method, reaction dynamics, and final material properties.

Outlined syllabus

Unit 1 Chemistry of Polymers

Polymers Fundamentals: Classification, nomenclature, molecular weight determination methods, and thermal properties (e.g., glass transition temperature, T_g).

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Development of Polymer Science, method of polymerization and its properties.

Unit 2 Vinyl Polymerization

Addition (Vinyl) polymerization:

Free radical polymerization -Mechanism and kinetics of freeradical addition polymerization.

Ionic polymerization - Types of ionic polymerization, common features, mechanism and kinetics of ionic polymerizations.

Unit 3 Special Polymerization techniques

Coordination polymerization (Ziegler-Natta polymerization), Ring opening and Ring-opening metathesis polymerizations.

Step (condensation) polymerization, Carothers equation, mechanism and kinetics of condensation polymerization.

Unit 4 Polymerization processes

Polymerization: Detailed mechanism and kinetics of various techniques: addition (free radical, ionic, coordination) and condensation polymerization. Bulk, solution, suspension and emulsion polymerization with examples. Melt, solution and interfacial polycondensations.

Polymer Technology: Compounding, processing techniques (injection molding, extrusion), and polymer degradation.

Reference Books

- 1.F. W. Billmeyer Jr., Textbook of Polymer Science, Wiley.
2. V. R. Gowariker, N. V. Viswanathan& J. Sreedhar, Polymer Science, New Age International.
3. Malcolm P. Stevens, Polymer Chemistry: An Introduction, Oxford University Press.
4. Joel R. Fried, Polymer Science and Technology, Prentice Hall.
5. George Odian, Principles of Polymerization, Wiley-Interscience.
6. R. J. Young & P. A. Lovell, Introduction to Polymers, CRC Press.
7. Seymour &Carraher, Polymer Chemistry: An Introduction, Marcel Dekker.

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Semester - III

Course Name: Plastic and Rubber Technology	Course Code: MSPS -302
Credit 4	Core Course - 10

Course Objectives

1. Different additives used for polymers.
2. Compounding of plastics and rubber materials.
3. Manufacturing processes used to produce different plastics and rubber moldings.
4. Chemistry, manufacturing methods and properties of some common plastic and rubber materials.

Course Outcome

After successful completion of the course, the students will be able to:

CO1: Explain the roles, types, and mechanisms of common additives used in plastics such as fillers, plasticizers, lubricants, stabilizers, colorants, and blowing agents.

CO 2: Describe and compare different plastic processing techniques including injection molding, compression molding, blow molding, rotational molding, extrusion, and calendaring.

CO 3: Discuss the manufacture, properties, and applications of important thermoplastics and thermosetting polymers such as polyethylene, polypropylene, PVC, PMMA, polyesters, polycarbonates, polyamides, and PTFE.

CO 4: Explain the principles of rubber chemistry and describe processing steps including mastication, mixing, compounding, molding, extrusion, calendaring, and vulcanization.

CO 5: Differentiate among various synthetic rubbers and evaluate their manufacture, properties, and industrial applications, including isoprene, butyl, butadiene, chloroprene, EPDM, thiokol, and silicone rubbers.

Course Description

This course provides a comprehensive understanding of plastics, additives, processing techniques, and rubber chemistry. Students will learn the functions and applications of key additives used in plastics such as fillers, plasticizers, flame retardants, colorants. The course covers major manufacturing and processing techniques including injection molding, extrusion, blow molding, compression molding, and calendaring.

Outline syllabus

Unit 1 Additives

Additives for plastics - fillers - plasticisers - lubricants and flow promoters - anti aging additives - flame retarders - colourants - blowing agents - cross linking agents - uvstabilisers.

Unit 2 Processing Techniques

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Processing techniques for plastics - injection moulding - compression moulding - blow moulding - rotational moulding - extrusion - calendering.

Unit 3 Some common plastics

Manufacture and properties of polyethylene - polypropylene - polystyrene - polyacrylonitrile - polymethylmethacrylate - polyesters - polycarbonate - polyamide - polyimide - polyurethane - polyureas - polyvinyl acetate - polyvinyl chloride – polytetrafluoroethylene - polyvinyl carbazole - thermosetting resins.

Unit 4 Rubber chemistry and technology

Introduction to rubber chemistry - Natural rubber - Outlines of rubber processing - Mastication, Compounding ingredients, Mixing, Moulding, Extrusion, Calendering and Vulcanisation - Properties of vulcanized rubbers - Manufacturing of rubber based articles and its applications.

Unit 5 Some common rubbers

Manufacture, properties and applications of Isoprene, Butyl, Butadiene, Chloroprene, EPDM, Thiokol and Silicon rubbers.

Reference Books

1. Joel R. Fried, Polymer Science and Technology, Prentice Hall.
2. R. J. Young & P. A. Lovell, Introduction to Polymers, CRC Press.
3. M. Chanda & S. K. Roy, Plastics Technology Handbook, CRC Press.
4. I. M. Ward & J. Sweeney, Mechanical Properties of Solid Polymers, Wiley.
5. A. R. Payne & J. B. Scanlan, Engineering with Rubber: How to Design Rubber Components, Hanser

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Semester - III

Course Name: Bioinorganic Chemistry/ Bio-organic Chemistry/ Biophysical Chemistry/ Natural Products	Course Code: MSPS-303A/ MSPS-303B/ MSPS-303C/ MSPS-303D
Credit 4	Discipline Elective course - 1

Bioinorganic Chemistry

Course Objectives

1. To describe about basic principles and importance of various metals in natural systems.
2. To describe various ion transport through biological membrane.
3. To explain the importance of Iron and Copper containing metallo-biomolecule.
4. To illustrate the chemistry of bio molecules like DNA and RNA.
5. To describe the bioinorganic chemistry of Molybdenum, Tungsten and Zinc containing Enzymes.
6. To describe the bioinorganic chemistry of Vitamin B12.
7. To describe the bioorganic chemistry of enzymes and Co-enzymes.
8. To describe the biophysical chemistry of biopolymers and their molecular weights.

Course Outcome

- CO1:** Explain the transport of ions through membrane
CO2: Predict the structure and mechanism of Fe and Cu containing metalloproteins.
CO3: Learn about structure and chemistry of DNA and RNA.
CO4: Understand the importance of Molybdenum, Tungsten and Zinc containing Enzymes.
CO5: Illustrate biologically important processes like photosynthesis
CO6: Understand the role and importance of metal ions in biology.
CO7: Explain the role of enzyme and co enzyme in reactions.
CO8: Learn about biopolymers and their molecular weights.

Course Description

This course includes details discussion about various bio molecules and metal containing enzymes with special reference to iron, copper, zinc, tungsten and molybdenum.

Outline syllabus

Unit 1 Bioinorganic Chemistry of Metals

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Essential and trace elements in biological systems,
structure and functions of biological membranes; mechanism of ion transport across membranes; sodium pump,
Role of calcium in blood clotting
Structure and functions of amino acids, proteins, peptides

Unit 2 Bioinorganic Chemistry of Iron and Copper

Iron-sulphur proteins: rubredoxin and ferredoxins;
Heme proteins: hemoglobin, myoglobin. Cytochrome P-450, Cytochrome c-oxidase and cytochrome
Synthetic oxygen carrier and model systems. Nonheme proteins: hemerythrin and hemocyanin.

Unit 3 Bioinorganic Chemistry in Biological Systems

A Metal complexes of polynucleotides, nucleosides and nucleic acids (DNA and RNA).

Stability of DNA and melting temperature.
Role of metal ions in replication and transcription process of nucleic acids.

Unit 4 Molybdenum, Tungsten and Zinc containing Enzymes

Enzymes and their classification; Importance of Zn in nature, carbonic anhydrase, carboxypeptidase, alcohol
dehydrogenase.

Biological nitrogen fixation (Nitrogenase) and abiological nitrogen fixation

Tungsten containing formate dehydrogenase and tungsten bearing hyperthermophilic enzymes.

Unit 5 Biologically Important Processes

Photosynthetic electron transport chain,
chlorophyll, PS-I and PS-II, Vitamin B 12 coenzyme, its function
Availability of iron and iron toxicity.

Reference Books

1. S. J. Lippard & J. M. Berg. Principles of Bioinorganic Chemistry; Panima Publ. Corp. (2005).
2. E. -I. Ochiai. Bioinorganic Chemistry; An Introduction; Allyn and Bacon Inc. (1977). Other References I.M. N. Hughes. The Inorganic Chemistry of Biological Processes; Wiley (1981).
3. R. P. Hanzlik. Inorganic Aspects of Biological and Organic Chemistry; Academic Press (1976).
4. H. Kraatz & N. Metzler-Nolte (Eds.). Concepts and Models in Bioinorganic Chemistry; Wiley (2006).
5. Bertini; H. B. Gray; S. J. Dippard & J. S. Valentine; Bioinorganic Chemistry; Viva Books Pvt. Ltd. (2004).
6. A. W. Addison; W.R. Cullen; D. Dolphin & B.R. James (eds.). Biological Aspects of Inorganic Chemistry; John Wiley (1977).

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Bioorganic Chemistry

Unit 1 Enzymes & Mechanism of Enzyme

Action Introduction and historical perspective, chemical and biological catalysis, properties of enzymes catalytic power, specificity and regulation. Fischer's lock and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed, mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition. Transition-state theory, acid-base catalysis, covalent catalysis, strain of distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

Unit 2 Kinds of Reactions Catalysed by Enzymes

Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and -cleavage and β elimination reactions, enolic intermediates in isomerization reactions, condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

Unit 3 Co-Enzyme Chemistry

Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD⁺, NADP⁺, FMN, FAD, lipoic acid, vitamin B12. Mechanisms of reactions catalyzed by the above cofactors.

Unit 4 Enzyme Models

Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crown ethers, cryptates. Cyclodextrins, cyclodextrin-based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes.

Unit 5 Biotechnological Applications of Enzymes

Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, use of enzymes in food and drink industry, brewing and cheese-making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

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Unit 6 Biological Cell and its Constituents

Cell Membrane and Transport of Ions Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition. Structure and functions of cell membrane, ion transport through cell membrane. II. Bioenergetics Standard free energy change in biological reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

Biophysical Chemistry

Unit 1 Biological Cell and its Constituents

Cell Membrane and Transport of Ions Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition. Structure and functions of cell membrane, ion transport through cell membrane.

Unit 2 Bioenergetics

Standard free energy change in biological reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

Unit 3 Statistical Mechanism in Biopolymers

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

Unit 4 Biopolymer Interactions

Thermodynamics of Biopolymer Solutions Forces involved in biopolymer interactions. Electrostatic charge and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibria and various types of binding processes in biological systems. Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.

Unit 5 Biopolymers and their Molecular Weights

Evaluation of size, shape, molecular weight and extent of hydration of biopolymers by various experimental techniques. Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, viscosity, electrophoresis and rotational motions

Reference Books for Bioinorganic Chemistry / Bioorganic Chemistry / Biophysical Chemistry

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.

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2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Bioinorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
4. Understanding Enzymes, Trevor Palmer, Prentice Hall.
5. Enzyme Chemistry: Impact and Applications, Ed. Colliins J Sucking, Chapman and Hall.
6. Enzymes Mechanism Ed, M.I. Page and A. Williams, Royal Society of Chemistry.
7. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
8. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
9. Enzymatic Reaction Mechanism, C. Walsh, W.H. Freeman.
10. Enzymatic Structure and Mechanism, W.H. Freeman.
11. Principles of Biochemistry, A.L. Lehninger, Worth Publishers.
12. Biochemistry, L. Stryer, W.H. Freeman. 13. Biochemistry, J. David Rawn, Neil Patterson.
13. Biochemistry, Voet and Voet, John Wiley.
14. Outlines of Biochemistry, E.E. Conn and P.K. Stumpf, John Wiley.
15. Macromolecules: Structure and function, F. World, Prentice Hall.

Natural Products Chemistry

Unit 1 Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure, determination, isoprene rule, Structure determination, stereochemistry biosynthesis and synthesis of the following representative molecules :Citral, Geraniol, α termpeneol Menthol, Farnesol, Zingiberen.

Unit 2 Alkaloids

Definition, nomenclature and physiological action, occurrence, isolation, general methods or structure elucidation, degradation, classification based on nitrogen heterocyclic rings, role of alkaloids in plants, Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, (+) Coniline, Nicoline, Atropine, Quinine and Morphine.

Unit 3 Steroids

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, Isolation, Structure determination and synthesis of Cholestrol, Bile acids, Androsterone, Testosterone, Estrone, Progestrone, Aldosterone, Biosynthesis of steroids.

Unit 4 Plant Pigments

Occurrence, nomenclature and general methods of structure determination, Isolation and synthesis of Apigenin, Luteolin, Quercetin, mytcelin, Quercetin-3-glucoside, Vitexin, Diadzein, Butein, Aureusin, Cyanidin -7-arabinoside, Cyanidin, Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

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Unit 5 Prophyris

Structure and synthesis of Haemoglobin and Chlorophyll.

Prostaglandins

Occurrence, biogenesis and physiological effects Synthesis of PGE₂ and PGF₂

Reference Books

1. Finar, I. L. Organic Chemistry (Volume 2: StereoChemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, PrajatiParakashan (2010).
3. Sujata V. Bhat, B.A. Nagasampagi, MeenakshiSivakumar, Springer Science & Business Media, 04-Jan-2005.

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Semester - III

Course Name: Nanochemistry / Organometallic Chemistry/ Chemistry/ Surface Chemistry	Course Code: MSPS-304A/ MSPS-304B/ MSPS-304C/ MSPS-304D
Credit 4	Discipline Elective course - 2

Nanochemistry

Unit 1 Fundamentals of Nanotechnology

Introduction to Nano-science and Nano-technology, Nano-scale material, implications for Physics, Chemistry, Engineering & Biology, and Motivation for Nanotechnology study. History & development of Nano-science and Nano-technology with the emphasis on history of Nano-metals, Chalcogenides & Boron Nitride and Carbon Nanomaterials

Unit 2 Structures & Classification of Nanomaterials

Nano-structures: various types of nano-structures and nano-crystals. Classification: of bulk Nanostructured materials, 0D, 1D, 2D structures – Size Effects – Fraction of Surface Atoms – specific Surface Energy and Surface Stress – Effect on the Lattice Parameter – Phonon Density of States Nano-particles, Quantum dots, Nano-wires, Ultra-thin films, Multi-layered materials.

Unit 3 Nanomaterials

Introduction: Properties of materials & nanomaterials, role of size and shape in nanomaterials. Electronic Properties: Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity. Magnetic Properties: Superparamagnetism, blocking. Important properties in relation to nanomagnetism.

Optical Properties: Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence. Thermal Properties and Mechanical Properties;

Unit 4 Synthesis and Characterization of Nanomaterials

Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Post-synthetic size-selective processing. Solgel, Micelles and microemulsions.

Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticles synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

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Characterization Techniques: X-ray diffraction, Scanning Probe Microscopy, SEM, TEM, Optical microscope and their description, operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers

Reference Books

1. C. Bre'chignac P. Houdy M. Lahmani, Nanomaterials and Nanochemistry, Springer Berlin Heidelberg, Germany (2006).
2. Kenneth J. Klabunde, Nanscale materials in chemistry, Wiley Interscience Publications (2001).
3. Hans Lautenshlager, Emulsions, Kosmetik International, (2002).
4. Roque Hidalgo-Alvarez, Structure and Functional properties of Colloids, CRC Press, (2009).
5. Richard J. Fann, Chemistry and Technology of Surfactants, Wiley-Blackwell, (2006)

Organometallic Chemistry

Unit 1 Alkyls and Aryls of Transition Metals

Alkyls and aryls of transition metals, nature of metal carbon bond, routes of synthesis, stability and decomposition pathways and their structure. Alkyls and aryls of s-block and p-block elements. Comparison of such transition and non-transition element derivatives. Organocopper in organic synthesis.

Unit 2 Compounds of Transition metal-carbon multiple bonds

Alkylidenes, alkylydines, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

Unit 3 Transition Metal π -Complexes

Transition Metal π -Complexes with unsaturated organic molecules. Alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes; preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

Unit 4 Homogeneous Catalysis

Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reaction, activation of C-H bond.

Unit 5 Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^2 -olefin, η^3 -allyl and dienyl complexes, their

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characterization.

Reference Books

1. Principle and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Heagsdus, J.P. 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.
5. Organometallic Compounds, NLH Green, Chapman & Hall, U.K.

Quantum Chemistry

Unit 1 Quantum Mechanics

Matter waves, The Uncertainty principle, the wave nature of the electron, Postulates of Quantum Mechanics, Commutation of operators, Eigen value and Eigen function. Angular momentum operator, Ladder operator. The wave equation, Particle in one dimensional box, particle in three-dimensional box, Degeneracy. Hydrogen atom: Schrodinger wave equation, Transformation of coordinates, separation of variable in polar spherical coordinates and its solution, probability distribution function, radial distribution function.

Unit 2 Prerequisite

Legendre, associated Legendre polynomials; Hermite polynomials; Lagurre and associated Lagurre polynomials; polynomials as orthonormal functions, their properties; step-up and step-down operators, application to single electron and multi-electron atom, eigen-ket-ladder and formulation of spherical harmonics from angular momentum rules, finite rotation operation vs. angular momentum operators, spin angular momentum, Pauli spin matrices — spin eigenfunctions and their properties. coupling of angular momentum for many electron system, spin-orbit coupling, Molecular term symbols. Quantum tunnel effect. Fermi and Bose gases.

Unit 3 Approximate methods

A Time dependent perturbation theory, semi classical treatment of radiation-matter interaction, transition probability and rates, Einstein's A and B coefficients, selection rules; Oscillator strength, Variation theorem and variational methods: principles of linear and non-linear variation methods, stationary perturbation theory for non-degenerate and degenerate states - applications to rotator, Stark effect.

Unit 4 Many electron systems

An Antisymmetry of many electron wave function, spin and spatial orbitals, Slater dESERminant; closed-shell

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and open-shell electron configurations; multi-electron pure spin state wave functions - examples with 2- and 3-electron systems, formulation of a multi-electron closed-shell electron configuration energy, introduction of core, Coulomb and exchange integrals with their properties - example of He atom, independent particle model, multi-electron atomic Hartree Hamiltonian and related SCF equations solution, Roothaan-Hartree-Fock method vertical ionization potential and Koopman's theorem; Problems with open shell systems. Restricted and unrestricted HF methods (elementary idea). discussion of electron correlation.

Reference Books:

1. Atkins P. W., Physical Chemistry, Oxford University Press, New York.
2. Levine I. N., Physical Chemistry, Tata McGraw Hill Pub. Co. Ltd., New Delhi.
3. Adamson A. W., Physical Chemistry of Surfaces, John Wiley and Sons. Other References 1. Day M. C. and Selbin J., Theoretical Inorganic Chemistry. 2. Pashley R. M. and Karaman M. E., Applied Colloid and Surface Chemistry, Wiley Publications.
4. Singh N. B., Gajbhiye N. S. and Das S. S. Comprehensive Physical Chemistry, New Age publishers, New Delhi.
5. McQuarrie D. A. and Simon J. D., Physical Chemistry.

Surface Chemistry

Unit 1 Surface Chemistry

Adsorption Surface tension, capillary actions, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces.

Unit 2 Surface Chemistry in Solid Liquid System

The Solid-Liquid Interface Surface energy from solubility changes, surface energy from immersion, contact angle, contact angle hysteresis, experimental methods and measurement of contact angle, theories of contact angle phenomena, adsorption of non-electrolytes from dilute solutions, irreversible adsorption, adsorption in binary liquid systems, adsorption of electrolytes.

Unit 3 Surface Characterization Techniques

Ultra-high vacuum for surface studies, Low energy electron diffraction, Photoelectron spectroscopy, Inverse photoemission spectroscopy, Scanning probe microscopy, Auger electron spectroscopy, Infrared spectroscopy, High resolution electron.

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Unit 4 Surface Chemistry and Micelles

A Surface tension and surface free energy; Pressure across an interface: Laplace equation, Kelvin equation. Adsorption in liquid systems: Gibbs adsorption isotherm; Adsorption on solids: Langmuir isotherm, BET isotherm.

Micelles-Surface active agents, micellization, hydrophobic interaction, critical micellar concentration (cmc), factors affecting cmc of surfactants, micro emulsions, reverse micelles

Reference Books

1. Somorjai, G.A.; Introduction to surface chemistry and catalysis, 2nd edition; 2010; WileyBlackwell.
2. Singh N. B., Gajbhiye N. S. and Das S. S. Comprehensive Physical Chemistry, New Age publishers, New Delhi.

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Semester - III

Course Name: Polymer Science Laboratory -1	Course Code: MSPS-305P
Credit 4	Practical course -5

Course Objectives

The main objective of this course is to:

1. Introduce students to different polymer preparation techniques such as bulk, solution, suspension, and emulsion polymerization.
2. Provide hands-on experience in polycondensation and interfacial polymerization methods for preparing industrially important polymers.
3. Develop practical skills in synthesizing polymers like polyurethane foams, Nylon-66, and Glyphtal resin.
4. Train students in the use of instrumental methods for polymer characterization, including IR, NMR, viscometry, and thermal analysis.
5. Strengthen students' abilities to analyze, interpret, and report experimental results in polymer science.

Course Outcomes

CO 1: Perform polymer preparation using bulk, solution, suspension, and emulsion techniques.

CO 2: Carry out polycondensation and interfacial polymerization reactions to synthesize polymers such as polyurethane foam, Nylon-66, and Glyphtal Ester.

CO 3: Explain and demonstrate the procedures and chemistry involved in forming commercially important polymers through laboratory methods.

CO 4: Analyze polymers using IR and NMR spectroscopy and determine molecular weight using viscometric methods.

CO 5: Record, document, and report experimental observations with scientific accuracy and safety compliance.)

Course Description

This laboratory course provides hands-on training in the preparation, processing, and characterization of polymers. Students will learn various polymer preparation techniques such as bulk, solution, emulsion, and suspension polymerization. The course includes experiments in polycondensation polymerization, interfacial polymerization, and formation of important polymers such as polyurethane foams, Nylon-66, and Glyphtal resins.

Outlined Syllabus

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A. Polymer preparations

1. Polymer preparation in bulk
2. Polymer preparation by solution method
3. Polymer preparation by emulsion method
4. Polymer preparation by suspension

B. Polycondensation Polymerization

Preparation of polyurethane foams

C. Interfacial and Condensation Polymerization techniques

Nylon-66 preparation and Glyphthal Ester formation.

D. Polymer Characterizations

1. IR and NMR spectra of polymers
2. Determination of molecular weight of polymer by viscosity
3. Thermal analysis of polymer

Reference Books:

1. J. R. Fried, *Polymer Science and Technology – Laboratory Experiments*, Prentice Hall.
2. M. P. Stevens, *Polymer Chemistry: An Introduction – Laboratory Experiments*, Oxford University Press.
3. D. Campbell & J. R. White, *Polymer Characterization: Physical Techniques*, Chapman & Hall.
4. T. R. Crompton, *Practical Polymer Analysis*, SmithersRapra Publishing.
5. G. Todo, *Introduction to Polymer Processing and Characterization Laboratory Manual*, Springer.
6. L. H. Sperling, *Introduction to Physical Polymer Science – Experimental Methods*, Wiley.

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Semester - III

Course Name: Polymer Science Laboratory - 2	Course Code: MSPS-306P
Credit 4	Practical course - 6

Course Objectives

1. Understand and perform different polymerization techniques, including bulk, solution, suspension, interfacial, and condensation polymerizations.
2. Synthesize a variety of polymers such as polystyrene, PMMA, polyurethanes, polyesters, and nylon-66.
3. Isolate, purify, and characterize polymers using analytical techniques.
4. Analyze polymer properties, including mechanical, thermal, and molecular weight characteristics.
5. Develop practical skills in laboratory techniques specific to polymer chemistry.
6. Correlate polymer structure, method of preparation, and properties for material design and applications..

Course Outcomes

Student will be able to

CO1: Demonstrate proficiency in bulk, solution, suspension, interfacial, and condensation polymerization methods.

CO2: Synthesize polymers with desired properties and evaluate their yield, structure, and morphology.

CO3: Perform and interpret polymer characterization using IR and NMR spectroscopy.

CO4: Determine molecular weight of polymers using viscometry and analyze thermal properties via DSC/TGA.

CO5: Assess the relationship between polymerization technique, molecular structure, and material properties.

CO6: Develop problem-solving skills and laboratory safety awareness specific to polymer synthesis and analysis.

Course Description

This laboratory course provides hands-on experience in the synthesis, characterization, and analysis of polymers. Students will learn various polymerization techniques, including bulk, solution, suspension, interfacial, and condensation polymerizations. The course emphasizes both step-growth (polycondensation) and chain-growth polymerizations, along with the preparation of commercially important polymers like polystyrene, poly(methyl methacrylate) (PMMA), polyurethanes, polyesters, and nylon-66. In addition, students will gain practical skills in polymer characterization using spectroscopic (IR, NMR), viscometric, and thermal analysis (DSC/TGA) methods. The laboratory sessions aim to reinforce theoretical knowledge, develop experimental skills, and cultivate an understanding of polymer properties in relation to their structure and preparation methods.

Outline Syllabus

A. Polymer Preparation Techniques

Bulk polymerization of styrene – Preparation and determination of yield.

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Solution polymerization of methyl methacrylate (MMA) – Isolation and analysis of PMMA.
Suspension polymerization of vinyl chloride or styrene – Preparation of beads and evaluation of particle size.

B. Polycondensation / Step-Growth Polymerization

Preparation of polyurethane foams – Study of foaming, density, and mechanical properties.
Preparation of polyester (e.g., polyethylene terephthalate) – Characterization of polymer formed.

C. Interfacial and Condensation Polymerization

Nylon-66 preparation by interfacial polymerization – Observation of polymer film formation, strand formation, and properties.
Glyphal ester resin synthesis – Study of condensation reaction and resin properties.

D. Polymer Characterization Techniques

IR spectroscopy of polymers – Functional group analysis of prepared polymers.
NMR spectroscopy of polymers – Structural identification and monomer sequencing.
Viscometric determination of molecular weight – Use of inherent viscosity to estimate polymer molecular weight.
Thermal analysis of polymers (DSC/TGA) – Study of thermal transitions, glass transition temperature (T_g), melting point, and thermal stability.

Reference Books:

1. Polymer Synthesis and Characterization: A Laboratory Manual — Stanley R. Sandler, Wolf Karo, JoAnne Bonesteel, Eli M. Pearce
2. Polymer Synthesis: Theory and Practice – Fundamentals, Methods, Experiments — Dietrich Braun, Harald Cherdron, Helmut Ritter, Matthias Rehahn, Brigitte Voit
3. Polymer Chemistry: A Practical Approach — Fred J. Davis
4. Introduction to Physical Polymer Science — Leslie H. Sperling
5. Polymer Reference Book — T. R. Crompton (covers analysis, instrumentation, polymer defect detection)
6. Polymers Synthesis and Characterization — Edited by Edina Rusen (MDPI) — includes step-growth, chain-growth, characterization, structure-property relationships

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Semester IV

Course Name: Applied Polymer Science	Course Code: MSPS-401
Credit 4	Core Course -11

Course Objective

1. Understand the chemistry and physical behavior of different types of adhesives.
2. Comprehend various polymer coating techniques and select appropriate coating systems for specific applications.
3. Analyze the structure, fabrication, and properties of polymer-based composites.
4. Investigate polymer latex types, properties, and applications, and compare them with polymer solutions.
5. Learn and evaluate modern recycling techniques and sustainable disposal methods for polymers.
6. Apply theoretical knowledge to practical problems in polymer applications and material selection.

Course Outcomes

CO1: Identify and describe the chemistry, types, and properties of structural, pressure-sensitive, rubber-based, contact, and hot-melt adhesives.

CO2: Select appropriate coating materials and methods based on performance requirements, including solvent-based, powder, and electrodeposition coatings.

CO3: Analyze composite materials, including matrix, reinforcements, and their interactions, and evaluate composite properties and applications.

CO4: Examine and compare polymer latex and polymer solutions, and determine latex properties relevant to industrial applications.

CO5: Assess and apply recycling techniques for polymers, including mechanical, chemical, and thermal methods, considering environmental sustainability.

CO6: Integrate knowledge of adhesives, coatings, composites, latex, and recycling to solve practical polymer technology problems.

Course Description

This course provides a comprehensive study of applied polymer materials, focusing on adhesives, coatings, composites, polymer latex, and recycling techniques. Students will explore the chemistry, physical properties, fabrication, and applications of structural, pressure-sensitive, rubber-based, contact, and hot-melt adhesives.

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The course covers various coating methods and materials, including solvent-based, high-solid, powder, and electrodeposition coatings. The properties and applications of polymer latex, as well as differences between latex and polymer solutions, will be examined. Finally, the course addresses modern polymer recycling techniques, including mechanical, chemical, and thermal methods, preparing students to consider sustainability in polymer processing and usage.

Outlined Syllabus

Unit 1 Adhesives

The chemistry and physical properties of structural adhesives, pressure sensitive adhesives, rubber based adhesives, contact bond (film) adhesives and hot-melt adhesives.

Unit 2 Coatings

Coating methods, solvent based coatings, roller coating, spray coating, high solid coatings, powder coatings, electrodeposition coating, properties and selection.

Unit 3 Composites

Types of composites – types of matrix - polymer-metal and ceramics. Types of reinforcements – glass, carbon and aramide - role of fibre and matrix - constituent and composite properties – fabrication, application of composites.

Unit 4 Polymer Latex

Introduction to polymer latex, classification of latex, comparisons and contrasts between polymer latex and polymer solutions, investigation of latex properties.

Unit 5 Recycling Techniques

Recycling techniques, size reduction, washing, identification and sorting of plastics, agglomeration, other methods of recycling and waste disposal options, chemical recycling, thermal conversion technologies.

Reference Books

1. Applied Polymer Science — Ulf W. Gedde, Mikael S. Hedenqvist, Minna Hakkarainen, Fritjof Nilsson, Oisik Das, Springer.
2. Applied Polymer Science — Asad Rahman (Ed.), Delve Publishing. delvepublishing.com
3. Applied Polymer Science: 21st Century — C. Craver & C. Carraher, Elsevier / Pergamon.
4. Advanced Polymer Science: Building Fundamentals to Understand Real-World Applications — Swati S.
5. Sharma, Manisha S. Bhende, Suvarna Patil, Himanshu Ranjan Verma, Routledge.
6. Rheology Applied in Polymer Processing — B. R. Gupta, CRC Press.
7. Applied Methodologies in Polymer Research and Technology — Abbas Hamrang, Devrim Balköse (Eds.), Apple Academic Press

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Semester - IV

Course Name: Green Chemistry/ Polymer Chemistry/ Material Chemistry/Computational Chemistry	Course Code: MSPS-402A/ MSPS-402B/ MSPS-402C/ MSPS-402D
Credit 4	Discipline Elective Course - 4

Course Objectives

With the environmental concern and shrinking resources acquiring enormous proportions, it has become imperative to devise safer alternative materials and technology that would ensure the human sustenance. This course intends to take the students through the newer, environment friendly products and procedures and incite them to take a more holistic view of different chemical processes.

Course Outcomes

- CO1:** Explain the field of green chemistry.
- CO2:** Acquire knowledge of the 12 principles of green chemistry.
- CO3:** Develop an understanding of cleaner production and green synthesis methods
- CO4:** Acquire the Knowledge of catalysis, and microwave theory.
- CO5:** Appreciate the Principle of Photochemical

Green Chemistry

Unit I Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry.Goals of Green Chemistry.Limitations/Obstacles in the pursuit of the goals of Green Chemistry. Definition and concepts: green chemistry; sustainable consumption of resources; individual and community level participation such as small-scale composting pits for biodegradable waste.

Unit 2 Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy).

Unit 3 Cleaner Production

The Cleaner Production Concept , Why Cleaner Production , Difference With End of Pipe Concept, Cleaner Production and Sustainable Development, Implementation of Cleaner Production , Change of

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Raw Material, Technology Change, Good Operating Practice, Product Change, On Site Reuse And Recycling, Who Is Responsible For Cleaner Production, Government Rules, Green Synthesis of Nano Particles.

Unit 4 Green Chemical Strategies for Sustainable Development

Areas of green chemistry, Reaction mass balance-Atom Economy, Evaluation for Chemical Reaction Efficiency, Green Solvents/ reaction Media, Catalysis and Bio catalysis. Microwave oven as a reactor, Theory of Microwave Heating.

Unit 5 Photochemical Degradation

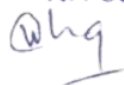
An Eco-friendly Approach of Waste Treatment

Photochemical Principles, Heterogeneous Photo-catalysis, Homogeneous Photo-degradation, photo oxidation, Direct Photo-degradation, Gas phase Detoxification, Equipments and applications.

Reference Books

- 1., P., and Williamson, T. C., Green Chemistry Frontiers in Benign Chemical Synthesis and Processes, Oxford University Press (1999).
- 2.Ahluwalia, V. K., and Kidwai, M., New Trends in Green Chemistry, Anamaya Publishers (2004).
- 3.Protective Groups in Organic Synthesis, Peter G. M. Wuts, T.W. Greene.
- 4.Sheldon, R.A., Arends, I., and Hannefed, U., Green Chemistry and Catalysis, Wiley-VCH Verlag GmbH and Co. (2007).

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Polymer Chemistry

Unit 1 Basics Importance of polymers

Basic concepts: Monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition, radical chain, ionic and co-ordination and co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogenous and heterogeneous systems.

Unit 2 Polymer Characterization

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weights. End-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers-chemical analysis of polymers, spectroscopic methods, X-ray diffraction study. Microscopy. Thermal analysis and physical testing tensile strength. Fatigue, impact. Tear resistance. Hardness and abrasion resistance.

Unit 3 Structure and Properties

Morphology and order in crystalline polymers, configurations of polymer chains. Crystal structure of polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties, crystalline melting point T_m , melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, T_g . Relationship between T_m and T_g , effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

Unit 4 Polymer Processing

Plastic, elastomers and fibres. Compounding. Processing techniques: Calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

Reference Books

1. Textbook of Polymer Science, F.W. Billmeyer Jr, Wiley.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R.M. Ottanbrite.
4. Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.
5. Physics and Chemistry of Polymers, J.M.G. Cowie, Blackie Academic and Professional

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Material chemistry

Unit 1 Multiphase Materials

Ferrous alloys; Fe-C phase transformations in ferrous alloys; stainless steels, non-ferrous alloys, properties of ferrous and non-ferrous alloys and their applications.

Unit 2 Glasses, Ceramics, Composites and Nanomaterials

Glassy state, glass formers and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Refractories, characterizations, properties and applications. Microscopic composites; dispersion-strengthened and particle-reinforced, fibre-reinforced composites, macroscopic composites. Nanocrystalline phase, preparation procedures, special properties, applications.

Unit 3 Thin Films and Langmuir-Blodgett Films

Preparation techniques; evaporation/sputtering, chemical processes, MOCVD, sol-gel etc. Langmuir-Blodgett (LB) film, growth techniques, photolithography, properties and applications of thin and LB films.

Unit 4 Liquid Crystals

Mesomorphic behavior, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic-nematic transition and clearing temperature-homeotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

Unit 5 Polymeric Materials

Molecular shape, structure and configuration, crystallinity, stress-strain behavior, thermal behavior, polymer types and their applications, conducting and ferro-electric polymers.

Unit 6 Ionic Conductors

Types of ionic conductors, mechanism of ionic conductors, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.

Unit 7 High Tc Materials

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Abhishek

Yashraj

Puneet

Renu

Defect perovskites, high Tc superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials, normal state properties; anisotropy; temperature dependence of electrical resistance; optical phonon modes, superconducting state; heat capacity; coherence length, elastic constants, position lifetimes, microwave absorption-pairing and multigap structure in high Tc materials, applications of high Tc materials.

Reference Books

1. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Saunders College.
2. Material Science and Engineering, An Introduction, W.D. Callister, Wiley.
3. Principles of the Solid State, H.V. Keer, Wiley Eastern.
4. Materials Science, J.C. Anderson, K.D. Leaver, J.M. Alexander and R.D. Rawlings, ELBS.
5. Thermotropic Liquid Crystals, Ed., G.W. Gray, John Wiley.
6. Handbook of Liquid Crystals, Kelker and Hatz, ChemieVerlag.
7. Inorganic Materials:Recent Advances,Editors D.Bahadur et al.,Narosa
8. Ion Conducting Materials: Theory and Applications, Editor A. R. Kulkarni, Narosa

Computational chemistry

Unit 1 Basic Computersystem

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High-Level languages (Machine language, Assembly language; QBASIC, C, C++, FORTRAN 90&95); Compiled versus interpreted languages. Debugging Software Products (Office, chemsketch, scilab, matlab, and hyperchem), internet application

Unit 2 Introduction to Python

Why Python? Python coding environment setup, Python as an interpreted language, Brief history of Python, Uses of Python (including artificial intelligence and machine learning), Applications of Python in Chemistry

Unit 3 Coding in Python

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(i) Basic syntax including constants and variables, Operators, Data Types, Declaring and using Numeric data types: int, float, string etc.

(ii) Program Flow Control Conditional blocks: if, else and else if, simple FOR loops, FOR loop using ranges, string, list and dictionaries. Use of while loops, Loop manipulation using pass, continue, break and else.

(iii) Complex data types: String, List, Arrays, Tuples and Dictionary, String operations and manipulation methods, List operations including slicing, in-built Python Functions.

(iv) Python packages - usage of numpy and scipy for mathematical computations.

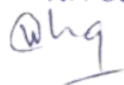
Unit 4 Numerical Methods in Chemistry

Solution of quadratic equation, polynomial equations (formula, iteration, Newton – Raphson methods and binary bisection) with examples of polynomial equations used in chemistry; Numerical differentiation – finite difference method (backward, central and forward), Numerical integration - Trapezoidal and Simpson's rule to calculate area under the curves for chemistry problems, e.g., entropy calculations, Simultaneous equations, Statistical analysis- mean, variance, standard deviation, error, Curve fitting – linear regression, Solving Schrödinger's equation using Python packages.

Reference Books

1. Computer Fundamentals by P.K. Sinha.
2. Fundamentals of Computers by V. Rajaraman.
3. Python Programming: An Introduction to Computer Science by John Zelle.
4. Numerical Methods for Scientists and Engineer by R.W. Hamming.
5. Computational Chemistry Using the PC by Donald W. Rogers

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Semester - IV

Course Name: Medicinal Chemistry/ Environmental Chemistry/ Photochemistry/ Supramolecular Chemistry	Course Code: MSPS-403A/ MSPS-403B/ MSPS-403C/ MSPS-403D
Credit 4	Discipline Elective Course - 4

Medicinal Chemistry

Unit 1 Drug Design

Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR) factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial considerations.

Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure activity relationship. History and development of QSAR.

Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constant, steric, Shelton and surface activity parameters and redox potentials.

Unit 2 Pharmacokinetics

Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process.

Unit 3 Pharmacodynamics

Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotic, biotransformation, significance of drug metabolism in medicinal chemistry.

Unit 4 Antineoplastic

Agents Introduction, cancer chemotherapy, special problems, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotics and mitotic inhibitors. Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards, and 6-mercaptopurine. Recent development in cancer chemotherapy. Hormone and natural products.

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Unit 5 Antibiotics

Cell wall biosynthesis inhibitors, β -lactam rings, antibiotics inhibiting protein synthesis. Synthesis of penicillin G, penicillin V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin.

Reference Books

1. Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH.
2. Wilson and Gisvold's: Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed. Robert F. Dorge.
3. An Introduction to Drug Design, S.S. Pandeya and J.R. Dimmock, New Age International.
4. Burger's Medicinal Chemistry and Drug Discovery, Vol-I, Ed. M.E. Wolff, John Wiley.
5. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
6. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
7. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.

Environmental Chemistry

Unit 1 Environment

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

Unit 2 Hydrosphere

Aquatic pollution- inorganic, organic, pesticides, agricultural, industrial and sewage, detergents, oil spills and oil pollutants. Water quality parameters-dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulphate, phosphate, nitrate and micro-organisms. Water quality standards. Analytical methods for measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg, Pb, Se etc.) residual chloride and chlorine demand. Purification and treatment of water.

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Unit 3 Soils

Composition, micro and macro nutrients, Pollution of fertilizers, pesticides and metals. Unit IV Atmosphere Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals chlorofluorohydrocarbons. Analytical methods for measuring air pollutants. Continuous monitoring instruments.

Unit 4 Industrial Pollution

Pollution from cement, sugar, distillery, drug; paper and pulp, thermal power plants, nuclear power plants, metallurgy, polymers and drugs etc.

Unit 5 Environmental Toxicology

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

Reference Books

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma and Kaur, Krishna Publishers.
3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
8. Environmental Chemistry, C. Baird, W.H. Freeman.

Photochemistry

Unit 1 Basics of photochemistry

Absorption, excitation, photochemical laws, electronically excited states-life times, measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative process, absorption spectra, Franck-Condon principle, photochemical stages-primary and secondary processes.

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Unit 2 Properties of Excited States

Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Biomolecular deactivation-quenching.

Unit 3 Excited States of Metal Complexes

Excited states of metal complexes: Comparison with organic compounds, electronically excited states of metal complexes. Charge-transfer spectra, charge transfer excitations, methods for obtaining charge transfer spectra.

Unit 4 Photosubstitution

Photo oxidation and photo reduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.

Unit 5 Redox Reactions by Excited Metal Complexes

Energy transfer under conditions of weak interaction and strong interaction-excipient formation; conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2'-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidizing character of Ruthenium²⁺, (bipyridyl complex, comparison with Fe (bipy)₃); role of spin-orbit coupling, life time of these complexes. Application of redox processes of electronically excited states for catalytic purpose, transformation of low energy reactants into high-energy products, chemical energy into light.

Unit 6 Metal Complex Sensitizers

Metal complex sensitizer, electron relay, metal colloid system, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

Reference Books:

1. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.
2. Inorganic Photochemistry, J. Chem. Educ., vol. 60, no. 10, 1983.
3. Progress in Inorganic Chemistry, vol. 30, ed. S.J. Lippard, Wiley.
4. Co-ordination Chem. Revs., 1975, 15, 321; 1981, vol. 39, 121, 131; 1990, 97, 313.
5. Photochemistry of Co-ordination Compounds, V. Balzari and V. Carassiti, Academic Press.
6. Elements of Inorganic Photochemistry, G.J. Ferraudi, Wiley.

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7. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern.
8. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
9. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
10. Introductory Photochemistry, A. Cox

Supramolecular Chemistry

Unit 1 Fundamentals of Supramolecular Chemistry

Terminology and definitions in supramolecular chemistry. Intermolecular forces: Ion pairing, ion-dipole and dipole-dipole interactions; hydrogen bonding; cation- π , anion- π , π - π interactions and Van der Waal forces. Solvent and solution properties, solvation and hydrophobic effect. Binding constants; definition and use, determination of binding constant by physical methods.

Unit 2 Molecular Recognition

Principle of molecular recognition, host-guest complementarity, preorganisation, chelate effect, cooperativity. Structure and function of receptors with molecular clefts, Synthesis and applications of supramolecular host with multiple hydrogen bonding sites (crown ethers, lariat ethers, podands, cryptands, spherands, calix[n]arenes, cyclodextrine, ionophores) as cation and anion binding receptors and receptors for ionpair recognition.

Unit 3 Reactivity and Catalysis

Organocatalysis mediated through hydrogen bonding, preconcentration, self-assembly of catalysts and preorganisation of catalyst-substrate systems. Influence of organization (effective molarity) on catalysis, Catalytic acyl transfer, acid-base catalysis, catalysis hydrolysis as ATPase mimic.

Unit 4 Applications of Supramolecular Materials

Basic principles and applications, Covalent organic frameworks, Metal organic frameworks, Host-guest complexation, micelles, polymers, Multifunctional catalysis.

Reference Books

1. Supramolecular Chemistry: from Molecules to Nanomaterials Eds. by P.A. Gale and J.W. Steed (2012).

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