M. Sc. CHEMISTRY SYLLABUS

Under Choice Based Credit System

(Effective from Academic Session: 2025-26)

MSCBU

POST GRADUATE DEPARTMENT OF CHEMISTRY
MAHARAJA SRIRAM CHANDRA BHANJA DEO UNIVERSITY
SRIRAM CHANDRA VIHAR
BARIPADA, ODISHA-757 003

MAHARAJA SRIRAM CHANDRA BHANJA DEO UNIVERSITY
COURSE STRUCTURE OF M. Sc. CHEMISTRY
Effective from Academic Session: 2025-26

SEMESTER	PAPER CODE	CREDIT	FULL MARK	INTERNAL ASSESSMENT	END SEM EXAM
FIRST	CH-101	5	100	40	60
	CH-102	5	100	40	60
	CH-103	5	100	40	60
	CH-104	5	100	40	60
	CH-105 (Practical)	5	100	30	70
	CH-IKS-106 (Indian Knowledge System)	2	50	20	30
	Life Skill Course	0	50	-	50
	TOTAL	**27**	**600**	**210**	**390**
SECOND	CH-201	5	100	40	60
	CH-202	5	100	40	60
	CH-203	5	100	40	60
	CH-204	5	100	40	60
	CH-205 (Practical)	5	100	30	70
	CH-206 (Open Elective)	5	100	40	60
	TOTAL	**30**	**600**	**230**	**370**
THIRD	CH-301	5	100	40	60
	CH-302	5	100	40	60
	CH-303	5	100	40	60
	CH-304 (Practical)	5	100	30	70
	CH-305 (SWAYAM MOOCS)	3 (Minimun)	100	40	60
	TOTAL	**23**	**500**	**190**	**310**
FOURTH	CH-401	5	100	40	60
	CH-402	5	100	40	60
	CH-403 (Practical)	5	100	30	70
	CH-404 (Project)	5	100	-	100
	TOTAL	**20**	**400**	**110**	**290**
	GRAND TOTAL	**100**	**2100**	**740**	**1360**

DISTRIBUTION OF INTERNAL ASSESSMENT MARKS

Maximum marks	Quiz	Mid Term	Assignment
40	**10**	**20**	**10**

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INSTUCTIONS FOR CONDUCTING INTERNAL AND END TERM EXAMINATIONS

(a) 1) 1st quiz- End of Unit-I
2) 2nd quiz- End of Unit-II
3) Midterm- End of Unit-III (Covering all three units), having 6 questions compulsory with 2 marks each from all three units and three questions of 4 marks each from which 2 to be answered covering all 3 units
4) Assignment- End of Unit-IV
5) End Term- After full course covered (Covering all five units) end term will have: 5 questions of 2 marks each which is compulsory, 4 questions to be answered out of 5 with 5 marks each and 3 questions to be answered out of 5 with 10 marks each. Each group to have one question from each unit. Questions are to be easy, little difficult and difficult type. The time duration for end term theory examination is of 03 hrs for each paper.

A: A teacher cam conducts three quizzes to consider the average of best two and also two assignments to consider the best one from among those.
B: Quizzes/Assignments can be conducted without prior notice. But a notice in general can be served to students to make them aware of quizzes without notice.

(b) 1. The questions in quizzes may be MCP but sets may be prepared for the class to avoid cheating in the class/team answering.
or The question may be with expected one-line answer
2. There shall be at least 10 questions and time should not exceed 10 minutes.

(c) The assignment should be done through class room presentation with one/two days prior information.

(d) For mid-term open book system may be adopted, provided questions encourage critical thinking or interpretation.

- The course will be attached with a lesson plan with hours of teaching for each unit and it must be provided to students at the beginning of the course preferably in the first class
- A student must know about the course and its outcome in advance

(e) 75% attendance is a must and there is no medical certificate provision. This is to be ensured as it is the statutory provision.

- A teacher needs to take the attendance within 15 minutes of the beginning of each class
- This is to ensure discipline and punctuality among students.

(f) The Marks distribution for End-Term examination of Indian Knowledge System (LKS) will be as follows-

1. $1 \times 5 = 5$ marks (All questions are compulsory)
2. $2 \times 5 = 10$ (02 Questions will be answered out of Five questions i.e. one from each Unit)
3. $3 \times 5 = 15$ (03 Questions will be answered out of Five questions i.e. one from each Unit)

PROGRAMME OUTCOMES (POs):

On completion of the programme (M.Sc. Chemistry) the students will be able to:

- Acquire conceptual knowledge and comprehensive understanding of the fundamental principles in respective discipline.
- Apply knowledge, understand and critically evaluate the concepts and scientific developments to take up any challenge towards teaching and research.
- Visualize and gain practical knowledge on multidisciplinary aspects related to current research in the fields of Chemical sciences.
- **A**cquire various skills so as to get motivated to innovate, design methods and techniques to carry out research.
- **C**ommunicate effectively, present and publish scientific ideas in Native and English language.
- Employ innovative and greener methods inculcating novel ideas to solve complex and challenging societal and environmental issues.

PROGRAMME SPECIFIC OUTCOMES (PSOS):

On completion of the specific programme, the student will be able to:

- Acquire confidence to face competitive examinations of national level like NET, GATE and capable of doing research independently. Utilize skills in problem solving, critical thinking, and analytical reasoning in chemistry.
- Enhance Skill in planning and conducting advanced level chemical experiments, elucidating the structure of compounds / complexes using chemical characterization techniques.
- Develop a creative scientific mind to communicate effectively in public forum-scientific ideas and their impact on socio-economic issues and also provide value based ethical leadership and sensitize the need for a green environment.
- Apply the knowledge of chemistry to effectively function as an individual / team leader / entrepreneur in academic field, chemical or related industries.
- Opt for two specializations namely Inorganic Chemistry and Organic Chemistry to specialize in their favorite subject.
- Opt for two supportive courses in Sem-II and Sem-III of 10 credits.

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SEMESTER-I

CH – 101 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

PHYSICAL CHEMISTRY-I
Marks- 60 (Theory Examination)

Course objectives:

- Learning about the formal theory of quantum mechanics and about its application to some simple systems as well as about the approximate methods and semi empirical methods.
- Learning about the theories of chemical reaction rates, kinetics and their control
- Learning about the electrochemistry of solutions, models on electrified interfaces and about corrosion and batteries.

UNIT–I (12 Hrs)

Quantum Chemistry-I: Foundations of quantum mechanics

Postulates of quantum mechanics: wave function and operators, commutation relations, construction of operators, eigen value equation, Hermitian operators, expectation value, the Schrodinger equation. Discussion of solutions of the Schrodinger equation for some model systems viz., particle in a box and the harmonic oscillator

UNIT- II (12 Hrs)

Quantum chemistry-II: Angular Momentum

Generalized (orbital, spin, total, rotational) angular momentum, addition of angular momentum in multi-electron systems (total L, S, spin-orbit), commutation relationships, eigenvalues and eigenfunctions of angular momentum operators; the rigid rotor, the hydrogen atom, electron spin and the hydrogen atom, the spin-statistics theorem and antisymmetry of electronic wavefunctions, the helium atom

UNIT- III (12 Hrs)

Quantum chemistry-III: Approximate Methods

The variation theorem, Linear variation principle. Perturbation theory (first order and non-degenerate). Applications of variation method and perturbation theory to the Helium atom ground state.

Molecular Orbital Theory: Huckel Theory of conjugated systems, bond order and charge density calculations, Applications to ethylene, butadiene, cyclopropenyl radical.

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UNIT - IV **(12 Hrs)**

Chemical Dynamics

Theories of reaction rates, collision theory of reaction, steric factor, activated complex theory, Arrhenius equation and the activated complex theory, ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions. homogeneous catalysis, kinetics of enzymes reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method.

UNIT – V **(12 Hrs)**

Electrochemistry

Electrochemistry of solutions Debye -Huckel - Onsager treatment and its extension, ion solvent interactions. Deby-Huckel-Jerum mode Thermodynamics of electrified interface equations. Derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination, Structure of electrified interfaces. Guay - Chapman, Stern, model. Over potentials, exchange current density, derivation of Butler Volmer equation, Tafel plot. Introduction to corrosion, Homegenous theory, forms of corrosion, corrosion monitoring and prevention methods. Batteries, primary and secondary fuel cells.

COURSE OUTCOMES:

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

- Realize and appreciate the wave-particle duality at microscopic level and the need of quantum theory, the significance of wave functions, eigen functions, eigen values and uncertainties
- Learn about the qualitative results from rigid rotor, harmonic oscillator and hydrogen atom problems.
- Learn about theories to approximately calculate eigenvalues and eigenfunctions through the variational and perturbation methods and apply these methods to the helium atom.
- Learn about different types of angular momentums – orbital, spin and total angular momentum of a single particle, rules for vector addition of these angular momentums for multiparticle systems like an atom.
- Learn and apply the semiempirical method of Huckel theory to conjugated molecular systems like ethylene, butadiene, etc and calculate their bond order and charge density.
- Acquire in depth knowledge about theories of chemical kinetics and to calculate specific rate, activation energy and frequency factor
- Acquire knowledge on unimolecular reactions, kinetics of enzyme reactions and study of fast reactions by different methods.
- Study of models on electrified interfaces such as Guay Chapman model and Stern model.
- Acquire knowledge on exchange current density, able to derive Butler Volmer equation and Tafel plot.
- Acquire knowledge on corrosion, Batteries and fuel cells.

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Book Recommended

1. Quantum Chemistry, Ira N.Levine, Prentice Hall
2. Molecular Quantum Mechanics, P.W. Atkins, R. Friedman, Oxford University Press
3. Introducation to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
4. Chemical Kinetics, K.J. Laidler, Mcgraw-Hill.
5. Kinetics and Mechanism of Chemical Transformations, J.Rajaraman & J.Kuriacose, McMillan.\.
6. Modern Electrochemistry Vol. I and Vol.ll J.O.M. Bockris and A.K.N.Reddy, Plenum.

CH – 102 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

INORGANIC CHEMISTRY-I
Marks- 60 (Theory Examination)

Course objectives:

- Learn about the various theories of complexes, basics of electronic spectroscopy of transition metal complexes, mode of coordination, reactivity and various symmetries & geometry.
- Learn the concept of symmetry element, symmetry operation and point groups.
- Learn about the preparation, structure and bonding of π acid complexes.

UNIT – I (12 Hrs)

Reactivity of metal complexes

Energy of a reaction, theromodaynamic and kinetic stability of metal complexes, kinetic applications of valence bond and crystal field theories.

Metal-Ligand Equilibria in Solution

Stepwise and overall formation constants and their interrelation, trends in stepwise constants, factors affecting the stability of metal complexes with reference to nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry, spectrophotometry, Job's method of continuous variation.

UNIT – II (12 Hrs)

Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh}, etc.groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use:

UNIT – III **(12 Hrs)**

Electronic Spectra and Magnetic Properties of Transition Metal Complexes

Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metals complexes (d^1 to d^9 states), calculations of Dq, B and β parametres, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active, metal chelates and their sterochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

UNIT – IV **(12 Hrs)**

Metal - Ligand Bonding

Limitations of crystal field theory, molecular orbital theory: sigma bonding and energy level diagram in octahedral, tetrahedral and square planar complexes; p-bonding and energy level diagram in octahedral complexes, angular overlap model.

UNIT – V **(12 Hrs)**

Metal π- Complexes

Metal carbonyls, structure and bonding, vibrational, spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand.

COURSE OUTCOMES:

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

- Discuss the kinetic applications of CFT and valence bond theory; describe the stability of metal complexes in terms of formation constant.
- Able to determine the binary formation constant by pH metry, spectrophotometry and Job;s method of continuous variation.
- Demonstrate detailed functional knowledge about the symmetry, bonding in octahedral and tetrahedral systems, spin orbit coupling and derive term symbols of free ions.
- Understand electronic transitions in metal complexes. interpret the spectra of coordination complexes and learn charge transfer spectra.
- Understand the angular overlap model to estimate amount of interaction takes place between metal d orbitals and ligand orbitals.
- Gain knowledge about the bonding of metal carbonyls, nitrosyls, dinitrogens and metal dioxygen complexes.

Books Recommended:

1. Advanced Inorganic Chemistry, Cotton and Wilkinson, John Wiley
2. Inorganic Chemistry, J.E. Huheey, Ellel A. Keiter, Richard L. Keiter & Okhil K.Medhi
3. Inorganic Chemistry, Gary L. Miessler and Donald A. Tarr

4. Symmetry and Spectroscopy of Molecules, K.V, Reddy
5. Chemical Application of Group Theory, F.A. Cotton

CH – 103 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

ORGANIC CHEMISTRY-I
Marks- 60 (Theory Examination)

Course objectives:

- To know about the stereochemistry of different types of molecules, reactions and their applications.
- Learn to appreciate the nexus between stereochemistry and conformational analysis of organic reactions.
- To learn and apply the fundamental concepts and mechanisms of organic reactions,
- To get a detail idea about various reaction mechanism
- To learn and understand the involvement of reactive intermediates, their structure and reactivity through various organic reactions.
- To know about the basic concept of aromaticity of the organic molecules.

UNIT – I (12 Hrs)

Stereochemistry, Structure and reactivity

Conformational analysis of decalins, effect of conformation on reactivity. Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, optical purity, enantioptic and diasterotopic atoms, groups and faces, stereospecific and steroselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. thermodynamic and kinetic requirements, kinetic and thermodynamic control, Curtin-Hammett principle, methods of determining mechanisms, isotope effects.

UNIT – II (12 Hrs)

Nucleophilic Substitution Reactions

The S_N2, S_N1, mixed S_N1 and S_N2 mechanisms. The neighbouring group mechanism, neighbouring group participation by Pi and sigma bonds, anchimeric assistance. Classical and non-classical carbocations, phenonium ions, norbornyl system, common carbocations rearrangements.

Substitution at an allylic, aliphatic trigonal ,vinylic carbon.

Substitution on aromatic substrates. Mechanism, reactivity, effects of substrate structure, attacking nucleophile, leaving group and reaction medium, The von Richter, Sommelet-hauser, and smiles rearrangements.

UNIT – III (12 Hrs)

Electrophilic Substitution Reaction

Bimolecular mechanisms on aliphatic substrates - The S_E1, S_E2 and S_Ei. Mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

Substitution on aromatic substrates-the arenium ion mechanism, orientation and reactivity, Quantitative treatment on reactivity in substrates and electrophiles. Diazonium coupling, Vilsmer reaction, Gattermann-Koch reaction.

UNIT - IV (12 Hrs)

Addition and Elimination Reaction

Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydrocarbonylation. Michael reaction. Sharpless asymmetric epoxidation. Mechanism of metal Hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organo zinic and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Witting reaction.

The E_2, E_1 and E_1CB mechanisms and their spectrum, Orientation of the double bond. Reactivity - effect of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

UNIT - V (12 Hrs)

Aromaticity and Reactive Intermediates

Huckel's rule and its application, Aromaticity in benzoid and non-benzoid compounds, Aromaticity of annulenes and heteroannulenes, Anti-aromaticity and Non-aromaticity

Carbenes: Generation, Property and structure of carbene, Carbene Insertion in C-H, O-H and C=C Bond and reactions involving carbene ; Nitrenes: Generation, Property and structure of Nitrenes, reactions involving nitrenes ((Beckmann, Hofmann, Schmidt, Lossen, Curtius); Ketenes: Generation, Property and structure of Ketene, reactions involving Ketenes

COURSE OUTCOMES:

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

- Ensures the students to understand and acquire knowledge on topicity and asymmetric synthesis.
- Describe the methods of asymmetric synthesis which involve chiral substrate, chiral reagents, chiral auxiliary and chiral catalyst.

- Demonstrate chirality in organic molecules using units such as center, axial, planar and helicity.
- Illustrate the reaction mechanism aspects in the context of addition, elimination and substitution reaction.
- Assess the structural effects of organic molecules and functional groups on the tendency to participate in various types of organic reactions.
- Predict whether a molecule is aromatic, anti-aromatic and non-aromatic.

Books Recommended:

1. Stereochemistry: Conformation and Mechanism: P. S. Kalsi, New Age International (p) Ltd. New Delhi
2. Stereochemistry of Organic Compounds: Principles and Applications: D. Nasipuri, New Age International Publishers
3. Basic Stereochemistry of Organic Molecules: Subrat Sengupta, Oxford University Press, 2014
4. Stereochemistry at a Glance: Jason Eames and Josephine Peach, Blackwell Science
5. Modern Organic Synthesis: An Introduction: George S. Zweifel, Michael H. Nantz and Peter Somfai, Wiley publications
6. Name reactions and rearrangements in organic synthesis: Bradford P. Munday, Michael G. Ellerd and Frank G. Favaloro, Wiley Interscience, 2nd Edition
7. Modern Methods of Organic Synthesis: William Carruthers, Cambridge University Press; 4th edition. 2015
8. Principles of Organic Synthesis: R. Norman and J. M. Coxon, 3rd Edition, CRC Publication
9. Advanced Organic Chemistry Part B: F.A. Carey and R.J. Sundberg, Plenum Press.
10. Organic Chemistry: Jonathan Clayden, Nick Greeves, Stuart Warren, Oxford University Press; 2nd edition 2014.
11. Organic Synthesis, Jagdamba Singh and L D S Yadav, Pragati Prakashan, Meerut, 2015
12. Organic Chemistry: Paula, Y. Bruice, 7th Edition, Pearson publication
13. Organic Chemistry-A mechanistic approach: Penny Chaloner, CRC Press
14. Organic Chemistry at a Glance: Laurence M. Harwood, John E. McKendrick and Roger C. Whitehead, Blackwell publishing

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CH – 104 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

POLYMER CHEMISTRY

Marks- 60 (Theory Examination)

Course Objectives:

- To know the basics of polymer Chemistry.
- To study on Polymer characterization along with structure and properties polymer
- To acquire knowledge on various methods of Polymer Processing
- T acquires knowledge on properties of commercial polymers.

UNIT – I (12 Hrs)

Basics

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

UNIT - II (12 Hrs)

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 weight. End-group, viscosity, light scattering, osmotic and ultracentrifugation methods.

UNIT – III (12 Hrs)

Structure and Properties.

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

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UNIT – IV **(12 Hrs)**

Polumer Processing

Compounding and processing techniques: Calendaring, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming

UNIT – V **(12 Hrs)**

Properties of Commercial Polymers

Polythylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins , electrically conducting polymers. Biomedical polymers - contact lens, dental polymers, artificial heart kidney, skin and blood cells.

COURSE OUTCOMES:

On completion of the course the student will be able to

- Acquire knowledge on basics of polymers and various polymerization processes.
- Characterize the polymers with respect to their molecular weight, viscosity and disparity.
- Measure molecular weight by different methods.
- Acquire knowledge on crystalline structure and various properties like melting point,chain flexibility of the polymers.
- Acquire knowledge on various applications of commercial polymers, electrically conducting polymers and biomedical polymers.

Books Recommended:

1. Text book 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.

CH-105 (5 Credits, 60 Hrs) **Marks-100 (30+70)**

INORGANIC GENERAL PRACTICAL

Course Objectives:

- To equip the students with analytical skills by analyzing the given inorganic salt mixture containing two common cations and two anoins.
- To perform systematic qualitative analysis with the strong theoretical back ground.
- To impart knowledge on the quantitative analysis of different metal ions.
- To enable the students to prepare simple complexes by using published reactions.

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1. Qualitative analysis

Analysis of Inorganic salt mixtures containing not more than six radicals (organic acid radicals should be excluded. One of the following rare metal ions like Mo, W, Ti, V and insoluble like TiO_2, $BaSO_4$ etc. may be included.

2. Quantitative Analysis

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

3. Preparations

Preparation of some selected inorganic compounds and handing of air and moisture sensitive compounds.

(i) $Mn(acac)_3$
(ii) $[Ni(NH_3)_6]Cl_2$
(iii) $K_3[Fe(C_2O4)_3]$
(iv) $Ni(dmg)_2$
(v) *Cis* - $K[Cr(C_2O_4)_2(H_2O)_2]$

COURES OUTCOMES:

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

- Prepare coordination complexes.
- Estimate amount of Fe and Cu in a mixture solutions of both.
- Estimate amount of Zn and Cu in a mixture solutions of both.
- Identify the unknown radicals present in a inorganic mixture.

Books recommended:

1. A Text book of Qualitative Analysis, A. I. Vogel
2. A Text book of Quantitative Analysis, A. I. Vogel
3. Inorganic synthesis, Vol. 1-20

CH-IKS-106 (2 Credits, 24 Hrs) **Total Marks- 50 (20+30)**

***Internal Assessment Examination (20 Marks)**

INDIAN KNOWLEDGE SYSTEM

Course Objectives:

- To help to study the enriched scientific Indian heritage.
- To learn and appreciate the contributions of ancient scientist for chemical science.
- To know the creative practices, skills and values in ancient Indian system in chemistry.

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UNIT-I **(5 Hrs)**

Chemistry in Ancient Indian Science

Vatsyana (4th to 6th Century CE), Nagarjuna (7th to 8th Century CE), AI-Biruni's India (11th Century), Rasannavakalpa (11th Century), Vagbhata (13th Century), Qualities of a teacher of Rasasastra, Location and building of rasasala, working arrangement of rasasala according to direction, material and equipment.

UNIT-II **(4 Hrs)**

Vaisesika and Chemistry

Classification of matter by Vaisesika, Padaartha, Dravya:Guna, Karma, Samanya, Visesa and Samavaya, Muni Kanada: Abhava, Anu, Kanada, Dharma.

UNIT-III **(5 Hrs)**

Theory of Atomic Combinations

Chemical combinations, Mono and hetero bhautika compounds, Theory of dynamic contact (Viśtambha), Chemical action and heat, Three axes of Vācaspati (graphical representation of constitution of a bibhautika compound), Conception of molecular motion (parispanda).

UNIT-IV **(5 Hrs)**

Ancient Indian Chemist and Chemical Entity

Kanad, Nagarjuna, Susruta, Kautilya, Chakrapani, Varahamihira, Acharya Prafulla Chandra Ray, Ancient Chemical Compounds (Dyes, Pigment, Cosmetics, Soap, Perfumes, Ink, Alcohols, Liquor) Use of Chemical compounds by Ancient Indian People (Iron, Dyes and Colour, Symmetry, Traditional medicines).

UNIT-V **(5 Hrs)**

Metals and Metallurgical Heritage

Arthaśāstra as the earliest text describing gold, silver and other metals. Processing of gold, silver, copper, iron tin, mercury, lead and Zinc as mentioned in Rasārnava and Rasaratnasamukāyā, Use of Au, Hg, Ag, Cu, and Fe as therapy in ancient India

COURSE OUTCOMES:

On completion of the course students will be able to:

- Learner will understand and appreciate the rich Indian Knowledge Tradition in chemical sciences.
- Learner will understand and appreciate the contribution of Indians in various fields.

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LIFE SKILL COURSE **Total Marks- 50**

Common Course to all Semester-I Students

Course Objectives:

- To promote confidence and well-being in young people.
- To learn how to analyze situations, evaluate options, and make informed decisions and fostering a mindset of critical thinking.
- To enhance communication skills among students.
- To make learn students about personnel safety and healthy life style choices.

SEMESTER - II

CH – 201 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

FUNDAMENTALS OF ANALYTICAL CHEMISTRY

Marks- 60 (Theory Examination)

Course Objectives:

- To learn the fundamental concepts and applications of various analytical techniques.
- To learn methods in statistical analysis.
- To understand principles and applications of Thermo gravimetric analysis (TGA), Differential Thermal analysis (DTA) and voltammetry.
- To understand principles behind solvent extraction.
- To understand underlying principles of ion chromatographic separation techniques and gain knowledge about HPLC principles.
- To learn methods in atomic absorption spectroscopy (AAS), Flame photometry and Nephelometric methods.

UNIT-I (12 Hrs)

Introduction

Role of analytical chemistry, classification of analytical methods: classical and instrumental, types of instrumental analysis, selection of analytical methods. Errors in analytical chemistry, classification of errors, source and minimization of errors, absolute and relative error, accuracy and precision, significant figures, mean value and deviation, average and standard deviation, median value, range, confidence intervals. Sampling in analysis: Definition, theory of sampling, technique of sampling, statistical criteria of good sampling, stratified sampling, transmission and storage of samples.

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UNIT-II **(12 Hrs)**

Solvent Extraction and ion exchange

Solvent Extraction: Principles, classification of extraction, mechanism of extraction, extraction equilibria, techniques of extraction, application in analytical chemistry.

Basic principles and applications of ion chromatograph and high performance liquid chromatography.

UNIT-III **(12 Hrs)**

Thermal analysis

Thermogravimetric analysis (TGA): Instrumentation, derivative thermo gravimetric analysis (DTG), application of theromogravimetry. Differential Thermal Analysis (DTA): Instrumentation and application of differential thermal analysis simultaneous TG-DTA curves. Thermogravimetric titration: Principle and applications.

UNIT-IV **(12 Hrs)**

Electroanalytical methods

Classification of electroanalytical methods, principles and applications of voltammetry, cyclic voltammetry, anodic stripping voltammetry, polarography, amperometry, coulometry, conductometry and ion selective electrodes. (Extensive instrumentations are to be excluded).

UNIT-V **(12 Hrs)**

Spectroscopic methods

Atomic adsorption spectroscopy: Principle and instrumentation, flame atomization, hollow cathode lamps, application of AAS in qualitative and quantitative analysis.

Flame photometric methods: Basic principle and instrumentation, interference in flame photometry, applications in quantitative analysis

COURSE OUTCOMES:

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

- Know about classification and selection of analytical methods, errors, accuracy, precision, mean, deviation and sampling.
- Learn about various electroanalytical and thermal techniques such as Thermo Gravimetric analysis (TGA), Differential Thermal analysis (DTA and Voltammetry.
- Familiarize with solvent extraction and ion exchange chromatography.
- Acquire knowledge about Atomic absorption spectroscopy (AAS), Flame photometry and Nephelometric methods.

Books recommended:

1. Analytical Chemistry, Gary D. Christian, 6th Edition, Wiley publication

2. Basic concepts of Analytical Chemistry, S. M. Khoopkar, New Age publication
3. Instrumental Methods of Chemical Analysis, H Kaur, Prati Prakashan
4. Analytical Chemistry, An Indian Adaptation, Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, Wiley India
5. Essentials of Analytical Chemistry, Ramakrishnan Shobha, Mukhopadhyay Banani, Pearson
6. Analytical Chemistry, C. Krupadanam, G.L.D. Vijaya Prasad, D. Varaprasad Rao, K. Reddy, K.L.N. Sudhakar, University Press

CH – 202 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

ORGANIC CHEMISTRY-II

Marks- 60 (Theory Examination)

Course objectives:

- To learn and understand the orbital interactions (Woodward Hoffmann rules) in pericyclic reactions and learn the fundamental ideas of photochemical excitation/de-excitation events, and the molecular events that can intervene at different levels and their applications.
- Frank-Condon principle and Jablonski diagram and apply the alpha cleavage or Gamma hydrogen transfer mechanism to organic molecules.
- Identify the mechanism of various photochemical reactions of alkenes, carbonyl compounds and aromatic compounds, and able to compare direct photolysis and sensitized photolysis reactions.
- To have an idea about various co-enzymes and enzyme catalyzed reactions
- To analyze and interpret molecular recognition process and concepts of supramolecular chemistry and understand the principles of biomimetic synthesis.

UNIT – I (12 Hrs)

Pericyclic Reactions

Molecular orbital symmetry, frontier orbitals of ethylene, 1,3- butadiene, 1,3,5 - hexatriene. Classification of pericyclic reactions. Woodward - Hoffmann correlation diagrams. FMO approach. Electrocyclic reactions- conrotatory - antrafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions. Sigmatropic rearrangements - suprafacial and antrafacial shifts of H, Sigmatropic shifts involving carbon moieties, 3,3 - and 5,5 - Sigmatropic rearrangements, Claisen, Cope and aza- Cope and Ene reaction.

MSCBU

UNIT-II **(12 Hrs)**

(a) Photochemical Reactions

Interaction of electromagnetic radiation with matter, type of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

(b) Photochemistry of Alkenes

Cis-trans isomerizations, Dimerization of alkenes, photochemistry of conjugated dienes, photoaddition of alkenes to aromatic benzoid compounds.

(c) Photochemistry of Carbonyl Compounds

Norrish type I and II cleavage, β-cleavage, photocycloaddition reactions, Parteno-Buchi reaction, photo rearrangement of cyclopentenone, cyclohexanone (Lumiketone, Di-π-methane type), dienones, β,γ-unsaturated ketones, Di-π-Methane rearrangement

UNIT – III **(12 Hrs)**

Photochemistry of Aromatic Compounds

Isomerisations, additions and substitutions.

Miscellaneous Photochemical Reactions

Photo-Fries reactions of anilides. Photo-Fries rearrangement. Barton reaction. Hoffman-Loefler-Freytag reaction, Singlet molecular oxygen reactions. Photochemical formation of smog. Photodegradation of polymers. Photochemistry of vision

UNIT - IV **(12 Hrs)**

Co-Enzyme Chemistry

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

UNIT – V **(12 Hrs)**

Enzyme Models

Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crownethers, cryptates. Cyclodextrins, cyclodextrin based enzymes models, calixarenes

COURSE OUTCOMES:

On completion of the course the student will be able to

- Predict and formulate the outcomes of pericyclic reactions in terms of orbital interactions and/or the Woodward-Hoffmann Rules & FMO approach of concerted reactions: Electrocyclic reactions, cycloadditions and sigmatropic rearrangements.
- Understand the phenomenon of light-matter interactions and principles of photochemistry.

- Understand the difference between radiative and non-radiative transitions with the help of Jablonski diagram.
- Predict the course of an organic photochemical reaction and identify the product with the type of functional group present on the molecule
- Understand the principles of molecular recognition and topological aspects of molecular receptors.
- Understand the principles of biomimetic chemistry involving crown ethers, cyclodextrin and calixarenes merged with catalysis.

Book Recommended:

1. Advanced Organic Chemistry Part A and Part B: F. A Carey, and R. J. Sundberg, Springer Publication, 5th edition, 2007
2. Pericyclic Reactions: A Text Book: S. Sankaraman, Wiley-VCH publication
3. Organic Photochemistry: B. Halton, and J. M. Coxon, Cambridge University Press, 2011
4. Photochemistry and Pericyclic Reactions, Jagdamba Singh and Jaya Singh, New Age International Publishers, 6th edition 2024
5. Pericyclic Reactions and organic photochemistry through Solved Problems: Satyajit Dey and Nirmal Kr. Hazra, Techno World Publication, 2019
6. Pericyclic Reactions: Ian Fleming, Oxford Chemistry Primers, 2nd edition, 2015
7. Fundamentals of Photochemistry: K. K. Rohtagi and K. K. Mukherjee, New Age International Publisher, 2021
8. Modern Molecular Photochemistry of Organic Molecules: Nicolas J. Turro, V. Ramamurthy and J. C. Scaiano, Viva Publication, 2017
9. Introductory Photochemistry, A. Cox and T. Camp McGraw-Hill

CH – 203 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

INORGANIC CHEMISTRY-II

Marks- 60 (Theory Examination)

Course objectives:

- To learn concepts of coordination chemistry and appreciate the importance of electronic spectroscopy and magnetic properties of coordination compounds.
- Have an understanding of various types of inorganic reaction mechanism in different geometries and environments.

- To acquiring knowledge on various types of electron transfer mechanism of metal complexes and their importance.
- Able to appreciate and learn some inorganic polymers, clusters and their bonding.
- To understand the key role of various metal ion in the living systems.

UNIT - I **(12 Hrs)**

Reaction Mechanism of Transition Complexes

Substitution reactions of octahedral complexes: acid hydrolysis, factors affecting acid hydrolysis; base hydrolysis, conjugate base mechanism, direct and indirect evidences in favor of conjugate mechanism; anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes: the trans effect and its application to synthesis of complexes, theories of trans effect, mechanism of substitution reaction and the factors affecting the substitution reactions.

Redox reactions: Outer-sphere reactions, Marcus theory for outer-sphere reaction, inner sphere reactions.

UNIT – II **(12 Hrs)**

Inorganic ring, cage and cluster compounds

Higher boranes, carboranes, metalloboranes and metallocarboranes, Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.

UNIT – III **(12 Hrs)**

Metal ions in Biological Systems

Essential and trace metals, role of alkali and alkaline earth metals, Inophores, Na^+-K^+ Pump, Transport of ions and its mechanism, Calcium in living cells and its transport & regulation

Metal ion transport and storage: Ferritin, Transferrin, Siderophores.

UNIT-IV **(12 Hrs)**

Bioenergetics and ATP Cycle

Metal complexes in transmission of energy; chlorophylls, photosystem-I and photosystem-II in cleavage of water. ATP as a energy currency in biological system .

(c) Metalloenzymes

Carbonic anhydrase, carboxypeptidase and vitamin B_{12}.

UNIT – V **(12 Hrs)**

Electron Transfer in Biology

Structure and function of metalloproteins in electron transport processes- cytochromes and ferrodoxin

Nitrogenase

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidences.

COURSE OUTCOMES:

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

- Understand structure, bonding, stablility and reactivity of simple boranes, carboranes and metallo carboranes, metal halide clusters and compounds with metal-metal multiple bonds.
- Evaluate and gain knowledge on various mechanism of substitution reactions in coordination complexes.
- Explain different types of electron transfer reactions and factors governing them.
- Know about ionophores, metal ion transport and storage protein like ferritine, transferrin and siderophores.
- Aquire knowledge on various metalloenzymes, metalcomplexes in transmission of energy, metalloproteins in electron transport processes and on biological nitrogen fixation.

Books Recommended:

1. Principles of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg, University Science Books.
2. Bioinorganic Chemistry, I Bertini, H.B.Gray, S.J.Lippard and J.S Valentine,University Science Books.
3. Inorganic Chemistry, J.E. Huheey, Ellel A. Keiter, Richard L. Keiter & Okhil K.Medhi.
4. Inorganic Chemistry, Gary L. Miessler and Donald A. Tarr.
5. Bioinorganic Chemistry. Asim K. Das
6. Hughes, M. N. The Inorganic Chemistry of Biological Processes, 2nd Ed., Wiley (1981).
7. Lippard, S. J. & Berg, J. M. Principles of Bioinorganic Chemistry Univ. ScienceBooks (1994).
8. Lippard, S. J. Progress in Inorganic Chemistry Vols. 18 and 38, Wiley-Interscience (1991).

CH – 204 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

SPECTROSCOPY-I

Marks- 60 (Theory Examination)

Course objectives:

- Learning about various aspects of atomic and molecular spectroscopy
- Gain insight into the spectral signals, their widths, their intensities and Fourier transform

spectroscopy.

- Students will learn the different spectroscopic fundamentals ranging from microwave to electronic transitions.
- To acquire intense knowledge about the basic principles of Rotational, Vibrational, and Raman spectroscopy.
- Learning detail understanding of principles of ESR and NMR spectroscopy.

UNIT – I **(12 Hrs)**

Introduction: Characterization of electromagnetic radiation, quantization of energy, regions of the spectrum, mechanism of light and mater interaction, representation of the spectra, components of a spectrometer, signal-to-noise ratio and resolving power, width and intensity of spectral transitions, Fourier transform spectroscopy

Microwave Spectroscopy: Classification of molecules, rotational energy levels of rigid diatomic molecule, intensities of spectral lines, effect of isotopic substitution, the non-rigid rotator

UNIT – II **(12 Hrs)**

Infrared Spectroscopy: Vibrational energies of diatomic molecules: simple harmonic oscillator, force constant and bond strengths, anharmonicity and Morse potential energy function, Vibration-rotation spectroscopy, selection rules, P, Q, R branches, breakdown of Born-Oppenheimer approximation, vibration of polyatomic molecules, normal modes of vibration, group frequencies, overtone and combination frequencies, influence of nuclear spin

UNIT– III **(12 Hrs)**

Raman Spectroscopy: Classical and quantum theories of Raman effect, polarizability and Raman activity of vibrations, mutual exclusion principle, pure rotational and vibrational Raman spectra, selection rules, rotational fine structure

Atomic Spectroscopy: Brief discussion of atomic structure, Hydrogen atom spectrum, spin-orbit coupling and fine structure of Hydrogen atom spectrum, spectra of Hydrogen-like species and alkali metals, many electron atoms, Term symbols, spectrum of Helium and alkaline earths.

UNIT – IV **(12 Hrs)**

Molecular Spectroscopy: Born-Oppenheimer approximation, Intensities of vibronic transitions, Frank-Condon principle, dissociation and predissociation of molecules, molecular orbitals, molecular term symbols, selection rules, spectrum of Hydrogen molecule, re-emission of energy by excited molecule: radiative and non-radiative decay

Photoelectron Spectroscopy: Basic principles, photoelectric effect, ionization process of atoms and molecules, Koopman's theorem, Auger electron spectroscopy- basic idea.

UNIT – V **(12 Hrs)**

Introduction to Spin Resonance Spectroscopy

Nuclear and electronic spin, interaction between spin and magnetic field, Larmor precession and nuclear magnetic resonance (NMR) and electron spin resonance (ESR), population of energy levels, relaxation time and width of signal, NMR spectroscopy: the chemical shift and coupling constant, coupling between several nuclei and the multiplet structure; ESR spectroscopy: the g factor, electron-nucleus coupling and hyperfine structure of ESR, McConnel equation and electron density distribution, application to methyl and benzene radical

COURSE OUTCOMES:

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

- Familiarize themselves about the basic elements of practical spectroscopy such as components of a spectrometer, resolving power, signal to noise ratio and Fourier transform spectroscopy.
- Learn about microwave activity of different types of molecules.
- Gain in-depth knowledge on rotational spectra of diatomic molecules using both rigid rotor and non-rigid rotor models. Apply these concepts to calculate different molecular properties.
- Get detailed insight into the infrared spectra of diatomic molecules by treating them using both harmonic and anharmonic oscillator model. Apply these concepts to calculate different molecular properties.
- Learn about Raman activity of molecules using the polarizability ellipsoids, analyze the rotational and vibrational bands in Raman spectra.
- Learn about the coarse spectra of hydrogen-like species, learn about their spectral fine structure. Learn about the term symbols in multi-electron atoms, and about the spectra of helium and alkaline earth metals.
- Understand the molecular spectra at dissociation and predissociation limits. Apply these concepts to understand the spectrum of the simplest molecule, H_2.
- Learn about the basic principles of photoelectron spectroscopy and apply to study spectra of simple molecules.
- Learn to explain NMR spectra through chemical shift and coupling of nuclear spins. Learn about the g-factor, electron-nucleus coupling and hyperfine structure.

Books Recommended

1. Fundamentals of molecular spectroscopy, C.N Banwell and E. M. McCash
2. Modern Spectroscopy, J.M. Hollas, John Wiley

3. Introduction to molecular spectroscopy, G .M Barrow
4. Introduction to photoelectron spectroscopy, P.K Ghosh
5. Atomic structure and chemical Bonding including molecular spectroscopy, Manas Chandra
6. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley interscience

CH – 205 (5 Credits, 60 Hrs) **Marks-100 (30+70)**

PHYSICAL GENERAL PRACTICAL

Course objectives :

- To learn the practical knowledge about the chemical kinetics, conductivity and potentiometric titrations using lab scale experimental methods.
- To motivate the students to understand the basic principles of chemical kinetics, potentiometric and conductometric titrations.
- To learn proper maintenance of record observations and data interpretation

CHEMICAL KINETICS

1. To determine the rate constant of acid catalysed hydrolysis of ethyl acetate by volumetric titration method.
2. To determine the rate constant of base-catalysed hydrolysis of ethyl acetate - by volumetric titration method.
3. To determine the bimolecular rate constant of the oxidation of iodide ions by hydrogen peroxide in aqueous medium.

HETEROGENEOUS EQUILIBRIA

1. To determine the partition coefficient of iodide between carbon tetrachloride and water.
2. To determine the equilibrium constant of the tri-iodide formation $I_2 + I^- \; I_3^-$ in aqueous solution.

CONDUCTOMETRY:

1. Conductometric titration of a mixture of HCL + CH_3COOH against NaOH.
2. To detrmine the rate constant of saponification of ethyl acetate - conductometrically
3. To determine the ionizatiion constant of weak acid.

POTENTIOMETRY

1. Potentiometric titration of a strong acid vs strong base.
2. Solubility product of a sparingly soluble salt.

POLARIMETER

1. To determine the rate constant of Inversion of cane sugar in acid medium.
2. To determine the concentration of unknown sugar.

SPECTROPHOTOMETER

1. Verification of Beer-Lambert's law.

COURSE OUTCOMES:

On completion of the course the student will be able to

- Determine the rate constant of acid catalysed hydrolysis of ethyl acetate by volumetric titration method.
- Determine the rate constant of base-catalysed hydrolysis of ethyl acetate - by volumetric titration method.
- Conductometric titration of a mixture of HCL + CH_3COOH against NaOH.
- Potentiometric titration of a strong acid vs strong base.
- Determine the rate constant of Inversion of cane sugar by polarimetry method and concentration of unknown sugar.
- Verification of Beer-Lambert's law and determination of extinction coefficient

Book Recommended:

1. Experimental Physical Chemistry by R.C. Das and B. Behera, Tata, Mc Graw Hill.

CH – 206 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

GENERAL ENVIRONMENTAL CHEMISTRY

Marks- 60 (Theory Examination)

Course Objectives:

- To know about pollutants, their hazardous effect and its remediation.
- To get detail concept about air, water, soil and radioactive pollution
- To get an insight to the role of various environmentally harmful substances and their biochemical effects.

MSCBU

UNIT - I **(12 Hrs)**

Introduction to Environmental Chemistry

Concept and scope of environmental chemistry, Environmental terminology and nomenclatures, Environmental segments

Atmosphere

Regions of atmosphere, Earth's radiation balance, chemistry of ozone layer, role of chemicals in ozone destruction, ozone hole, green-house gases and its effect, Global warming, measures to check global warming, El-Nino phenomenon.

UNIT - II **(12 Hrs)**

Air Pollution

Air Pollutants: sources, classification, sampling and monitoring. Aerosols, Acid Rain, Photochemical smog, Auto exhausts, Air-quality standards.

UNIT – III **(12 Hrs)**

Water Pollution

Water pollutants (sources, sampling and monitoring), Water-quality parameters and standards: physical and chemical parameters (colour, odour, taste and turbidity). Effects of fluoride in drinking water. Fresh water conservation in India.

UNIT – IV **(12 Hrs)**

Chemical Toxicology

Toxic chemicals in the environment, impacts of toxic chemicals on enzymes, biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, pesticides, insecticides and carcinogens. Bioaccumulation and biomagnifications.

UNIT – V **(12 Hrs)**

Radioactive Pollution

Introduction, Radioactive Pollution, Sources of Radioactive Pollution, Effects of Radioactive Pollution, Disposal of Radioactive Waste.

COURSE OUTCOMES:

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

- Understand the scope of environmental chemistry and its basic terminology.
- Understand ozone destruction, green-house effect, global warming and El-Nino effects.
- Understand sources, classification and monitoring of air pollution.
- Able to identify water pollutants and understand water quality parameters.
- Understand phenomenon like acid rain, photochemical smog.
- Identify effect of metals and other toxic pollutants and their biochemical effects.

MSCBU

- Understand Bioaccumulation and biomagnifications process.

Books Recommended:

1. Environmental Chemistry , S.E. Manahan, Lewis Publishers
2. Environmental Chemistry, Shariha & Krishna Publishers
3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
5. Standard Method of Chemical Anal., F.J. Welcher Vil. - 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
9. Hand Book of Environmental Analysis, Pradyot Patnaik, Lewis Publishers (1997)
10. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, Washington D.C. 20005, USA, 17th Edition (1998)

SEMESTER - III

CH – 301 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

ADVANCED ENVIRONMENTAL CHEMISTRY

Marks- 60 (Theory Examination)

Course objectives:

- To create awareness on environmental pollution.
- Understand human interaction and its impact on the environment.
- Understand various photochemical reactions in the atmosphere.
- To know about pollutants, their hazardous effect and its remediation.
- To get comprehensive knowledge about air, water, and soil pollution.
- To study the basic principles of green chemistry and their applications.
- To understand the application of green chemistry in sustainable development

UNIT – I **(12 Hrs)**

Environment

Introduction, Earth, Environment, Types of Environment, Environmental Segments, Vertical Temperature of Atmosphere, Heat Budget of Earth's Atmospheric System, Human

Interference with Environment, biogeochemical cycles in environment: water, carbon, oxygen and nitrogen.

UNIT – II **(12 Hrs)**

Atmosphere

Chemical Composition of Atmosphere**:** Introduction, Particulates, Ions, Radicals, Smog Chemical and Photochemical Reactions in the Atmosphere**:** Introduction, Oxygen, Ozone, Nitrogen, Oxides of Nitrogen, Oxides of Sulphur, Oxides of carbon.

UNIT - III **(12 Hrs)**

Soil Pollution

Introduction, Formation of Soil and its Characteristics, Soil Profile, Types of Soil, Alkaline, Acidic, and Neutral Soil, Plant Nutrients, Environmental Concerns of Soil Pollution, Harmful Effects of Soil Pollution.

UNIT – IV **(12 Hrs)**

Water Pollution

Types of Water Pollutants, Water, Pollution in Various Water bodies, Harmful Effects of Water Pollution, Sewage and Domestic Wastes, Industrial Effluents, Agricultural Discharge, Detergents, Toxic Metals.

UNIT – V **(12 Hrs)**

Green Chemistry

Basic concept, History, rules of green chemistry, Environmental impact, pollution control, industrial applications of green chemistry. Applications of Green Chemistry in Sustainable development.

COURSE OUTCOMES:

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

- Understand types of environment and human interference with the environment
- Describe various photochemical reactions in the atmosphere.
- Describe soil profile and harmful effects of soil pollution.
- Describe source and effects of radioactive pollution, and disposal of radioactive waste.
- Identify effect of metals and other toxic pollutants in the environment and their effect on human health.
- Outline the principles of green chemistry and its industrial applications.
- Understand application of green chemistry in sustainable development.

MSCBU

Books Recommended:

1. Advanced Environmental Chemistry, V K Ahluwalia, Teri (The Energy and Resource Institute), 2017
2. Environmental Chemistry , S.E. Manahan, Lewis Publishers
3. Environmental Chemistry, Shariha & Krishna Publishers
4. Environmental Chemistry, A.K. De, Wiley Eastern.
5. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Environmental Chemistry, C. Baird, W.H. Freeman

CH – 302 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

PHYSICAL CHEMISTRY-II

Marks- 60 (Theory Examination)

Course Objectives:

- Learning about classical and statistical thermodynamics, and their importance
- Learning about open and closed thermodynamic systems, partial molar properties
- Learning about ensembles, ensemble averages, partition functions and expression of thermodynamical quantities in terms partition functions and their applications
- Learning about non-equilibrium thermodynamics where we study about change of thermodynamic properties with time

UNIT – I (12 Hrs)

Classical thermodynamics

Brief resume of law of thermodynamics, free energy in closed system, thermodynamics of open systems: partial molar properties, chemical potential, Gibbs-Duhem equation, chemical potential and its relations to other partial molar properties and phase equlibrium, chemical potential of a system of ideal gas, determination of partial molar volume: slope and intercept method, concept of fugacity and determination of fugacity of a gas. Activity, activity coefficient, ionic strength

UNIT-II (12 Hrs)

Equilibrium statistical thermodynamics

Concepts: distribution of molecular states, microstates and macrostates of a system, equilibrium state and entropy, most probable distribution, canonical ensemble, grand canonical and microcanonical ensemble, time average and ensemble average of thermodynamic property

Statistical distribution formula: Bose-Einstein statistics, Fermi-Dirac statistics, Maxwell-Boltzman statistics

UNIT – III **(12 Hrs)**

Partition functions

Boltzman factor and partition function, atomic and molecular partition functions: electronic, translational, rotational and vibrational partition functions; canonical partition function for a system of non-interacting particles (distinguishable and identical particles), thermodynamic properties (internal energy, pressure, entropy, enthalpy, free energy, etc) in terms of canonical ensemble partition function

UNIT-IV **(12 Hrs)**

Application of partition function

Application to a system of monoatomic and diatomic ideal gas, heat capacity behavior of monoatomic crystals: Einsten and Debye theory, equilibrium constant of ideal gas reactions in terms of partition functions.

UNIT-V **(12 Hrs)**

Non-equilibrium thermodynamics

Fluxes and forces in irreversible processes, Phenomenological laws and Onsager's reciprocal relations, entropy production in spontaneous processes - due to flow of heat and matter, Prigogines principle of minimum entropy production

COURSE OUTCOMES:

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

- Differentiate between thermodynamics of closed and open systems. Learn about free energy in closed system as opposed to partial molar properties and chemical potential in open systems. Learn about the concept of fugacity and its determination for a real gas by graphical method.
- Learn about the concepts in statistical thermodynamic such as, distribution of molecular states, microstates and macrostates of a system, equilibrium state and entropy, most probable distribution. Derive the statistical distribution formula for Maxwell-Boltzman statistics, Fermi-Dirac statistics and Bose-Einstein statistics.
- Derive expressions for atomic and (diatomic) molecular partition functions for different degrees of motion: electronic, translational, rotational and vibrational partition functions. Derive and express thermodynamic properties in terms of ensemble partition function.
- Apply of the concept of partition function to evaluate thermodynamic properties of some realistic systems. Study of heat capacity behavior of monoatomic crystals using Einstein and Debye theory. Learn about the thermodynamics of systems that are not in equilibrium and

about spontaneous processes. Derive expression for entropy production in spontaneous processes both due to flow of heat and matter.

Books Recommended

1. Molecular Thermodynamic by D. A. McQuarrie and J. D. Simon
2. Physical Chemistry by Ira N Levine
3. Physical Chemistry by P. Atkins and J. de Paula
4. Statistical Thermodynamics by M.C. Gupta
5. Fundamentals of Statistical Mechanics by B. B. Laud
6. Introduction to Modern Statistical Mechanics, by D. Chandler, Oxford University Press (NY)
7. An introduction to Statistical Thermodynamics by T. L. Hill Dover (NY)

CH – 303 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**
(Elective-I, Group-A)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

ORGANIC SYNTHESIS - I

Marks- 60 (Theory Examination)

Course Objectives:

- Learn Organometallic Reagents serve as powerful reagents for constructing carbon-carbon bonds, facilitating transformations that were once considered challenging or impossible
- Get a detail idea about various oxidizing and reducing agents and their applications in organic transformations.
- Know the applications of metal catalyzed organic transformations and principles of heterocyclic synthesis.
- To learn the name reactions and rearrangements.

UNIT – I (12 Hrs)

Organometallic reagent

Application of organometallic reagent in organic synthesis: Group - I and Group - II metal : Li, Mg, and Zn. Transition metals : Cu, Pd, Ni, Rh and Other elements Si and B. Metal catalyzed coupling reactions (Heck coupling, Suzuki coupling, Negeshi Coupling, Stille coupling, Hiyama coupling, Kumada Coupling, Tsuji-Trost Coupling and Sonagashira coupling), Grubb's catalyst, Metathesis reactions .

UNIT - II (12 Hrs)

Oxidation

Use of modern Methods, reactivity, selectivity and representative examples in oxidation of hydrocarbons: Alkanes, Alkenes (m-CPBA, H_2O_2/OH^-, Wacker, ozonolysis, hydroboration oxidation, oxymercuration-demercuration, SeO_2, , OsO_4, $KMnO_4$, Sharpless, prevost, woodward Dioxiranes, Lemieux), Alkynes and aromatic hydrocarbons, oxidation of alcohols [Cr-based reagents (CrO_3, Jones, Collin's, PCC, PDC), sulfur based reagents (Swern, Mofatt, Corey-Kim, Parikh-Doering, Kornblum), Mn-based reagents (MnO_2, $KMnO_4$), Ag-based reagents (Fetizon,) and iodine based reagents (DMP, IBX, HIO_4, $NaIO_4$), TEMPO, CAN, DDQ, Oppenauer], oxidation of carbonyl compounds and their derivatives (Baeyer Villiger, Haloform,), oxidation with ruthenium and thallium (III) nitrate

UNIT - III (12 Hrs)

Reduction

Use of modern methods, reactivity, selectivity and representative examples in reductions of hydrocarbons: alkenes (catalytic hydrogenation, Wilkinson, diimide, BH_3, electron transfer), alkynes (catalytic hydrogenation, boron derivatives, electron transfer), aromatic hydrocarbons (Birch), hydrogenolysis, reduction of carbonyl compounds [$NaBH_4$, Luche, $NaCNBH_3$, BH_3 and its derivatives, $LiAlH_4$, $Li(OEt)_3AlH$, DIBAL, dissolved metal reduction, Wolff-Kishner, Clemmenson, Mozingo,), reduction of carbonyl derivatives ($ZnBH_4$, BH_3 and its derivatives), reduction using trialkyltin derivatives

UNIT – IV (12 Hrs)

Name Reactions and Molecular Rearrangement

Mechanism and Applications of Bamford-Stevens, Corey-Fuchs, Corey-Winter, HWE olefination, Mitsunobi, Mukaiyama Aldol, Peterson, Julia, Stork enamine

General mechanistic consideration, nature of migration, migratory aptitude, A detail study of Arndt-Eistert Synthesis, Beckmann, Bayer-Villiger, Curtius, Favorski, Wagner-Meerwein, Schmidt, Shapiro reaction, and Wittig.

UNIT – V (12 Hrs)

Heterocycle synthesis

Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions involving small ring heterocycles Three-membered and four-membered heterocycles-synthesis and reaction of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes.

COURSE OUTCOMES:

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

- Assess the mechanism and synthetic uses of selected organometalic reagent in organic synthesis.

- Predict the structure, mechanism and stereochemistry of reactions involving selected oxidizing and reducing agents on organic molecules.
- Understand the principles of constructing small ring (three and four membered) heterocycles involving cyclization and cycloaddition reactions.

Books Recommended:

1. Modern Organic Synthesis: An Introduction: George S. Zweifel, Michael H. Nantz and Peter Somfai, Wiley Publication
2. Name Reactions and Rearrangements in Organic Synthesis: Bradford P. Munday, Michael G. Ellerd and Frank G. Favaloro, Wiley Interscience, 2nd Edition
3. Modern Methods of Organic Synthesis: William Carruthers, Cambridge University Press; 4th edition. 2015
4. Principles of Organic Synthesis: R. Norman and J. M. Coxon, 3rd Edition, CRC Publication
5. Advanced Organic Chemistry Part B: F. A. Carey and R. J. Sundberg, Plenum Press.
6. Organic Chemistry: Jonathan Clayden, Nick Greeves, Stuart Warren, Oxford University Press; 2nd edition 2014
7. Organic Synthesis, Jagdamba Singh and L. D. S. Yadav, Pragati Prakashan, Meerut, 2015
8. Heterocyclic Chemistry, Raj K. Bansal, New Age International Publishers, 6th Edition, 2019
9. Heterocycle Chemistry: J. A. Joules and K. Mills, Wiley Publication, 5th Edition
10. Organic Chemistry at a Glance: Laurence M. Harwood, John E. McKendrick and Roger C. Whitehead, Blackwell publishing
11. Name Reactions-A Collection of Detailed Mechanism and Synthetic Applications: Jie Jack Li, Springer Publications, 6th edition 2021

CH – 303 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**
(Elective-I, Group-B)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

PHOTOINORGANIC AND SUPRAMOLECULAR CHEMISTRY

Marks- 60 (Theory Examination)

Course objectives;

- To understand characteristics of the electronically excited states of metal complexes.
- To learn various types of photochemical reactions of coordination compounds and solar energy conversion in semiconductor systems.

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- To understand various photoelectochemical process such as water-photolysis, nitrogen fixation and CO_2 reduction.
- To understand photochemical reactions substitution and redox reactions.
- Knowledge of various photochemical electron transfer in metal complexes.
- To gain an insight of fundamental principles of molecular recognition and supramolecular chemistry.
- To learn principles of design and synthesis of complex supramolecular architectures functional materials by utilizing non-covalent interaction.
- To gain an insight of self-assembly process, its behavior and applications in areas as transport process, catalysis and supramolecular devices.

UNIT – I **(12 Hrs)**

Excited state of Metal complexes

Excited state of Metal complexes, comparison with organic compounds, electronically excited states of metal complexes, CT spectra, CT excitations.

Metal complex sensitizers:

Metal complex sensitizers**,** Electron relay, metal colloid systems, semiconductor supported metal oxide systems, water-photolysis, nitrogen fixation and CO_2 reduction.

UNIT – II **(12 Hrs)**

Redox Reactions in Metal Complexes

Redox reactions of metal complexes in excited states, excited electron transfer, examples using $[Ru(bpy)_3]^{2+}$ complex and $[Fe(bpy)_3]^{3+}$ complex. Role of spin-orbit coupling, life-times of excited states in these complexes.

Introductory idea of Photo Chemistry of transition metal carbonyls with examples.

UNIT – III **(12 Hrs)**

Ligand Field Photochemistry

Photo substitution, Photo oxidation and Photo reduction of Cr (III) and Co (III) Complexes, 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 – IV **(12 Hrs)**

Fundamentals of Supra molecular Chemistry

Concept of Supramolecular Chemistry, Supramolecular Structure through non covalent interactions

Molecular recognition: Molecular receptors for neutral, cationic and anionic substrates, design and synthesis of co-receptors and multiple recognition,

UNIT – V **(12 Hrs)**

Applications of Supra molecular Chemistry

Self assembly in Supra Molecular Chemistry with Examples, Supramolecules in transport processes and carrier design, Supramolecular reactivity and catalysis, Supramolecular devices, Supra molecular photochemistry, Supra molecular electronic, ionic and switching devices.

COURSE OUTCOMES:

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

- Describe electronic absorption spectra of inorganic compounds and characteristics of the electronically excited states of inorganic compounds.
- Gain an understanding of various photoelectochemical process such as water-photolysis, nitrogen fixation and CO_2 reduction and solar energy conversion in semiconductor systems.
- Learn excited state of metal complexes and chemistry behind charge transfer spectra, charge transfer excitation and metal complex sensitizers.
- Know about redox reactions of metal complexes in excited states and life-times of excited states and introductory idea of photo chemistry of metal carbonyls.
- Learn principles of molecular recognitions process and design of inorganic functional molecular structures.
- Understand principles of recognitions with various receptors for neutral, cationic and anionic substrates, design and synthesis of co-receptors and multiple recognition and supramolecular self assembly process.
- Appreciate application of self assembly in transport processes and carrier design, reactivity and catalysis, electronic, ionic switching devices.

Books recommended:

1. An Introduction to Supramolecular Chemistry, Asim K. Das & Mahua Das
2. Progress in Inorganic Chemistry, Vols. 18 and 38 ed.
3. Supramolecular Chemistry - J.M. Lehn, VCH
4. Inorganic photochemistry, J. Chem Education, Vol. 60, No. 10, 1983.
5. Photochemistry of Coordination compounds, V. Balzari and V. Carassti, Acdemic Press

CH – 303 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

(Elective-I, Group-C)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

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BIOPHYSICAL CHEMISTRY

Marks- 60 (Theory Examination)

Course objectives:

- The course aims to provide all information necessary to understand the properties of biological macromolecules and the interactions responsible of their biological function.
- To provides an introduction to the principles of physical chemistry as applied to biological molecules and systems with and understanding of the physical-chemical basis for biological processes.

UNIT – I (12 Hrs)

Biological cell and its constituents

Biological cell, Structure and functions of proteins, enzymes, DNA and RNA in living systems, Helix coil transition.

Bioenergetics

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

UNIT-II (12 Hrs)

Statistical mechanics in bioplolymers

Chain configuration of macromolecules, Statistical distribution end to end dimensions, calculation of average dimensions for various chain structures, Polypeptides and protein structures, Introduction to protein folding problem.

UNIT - III (12 Hrs)

Bioploymer interactions

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

Thermodynamics of bioploymer solutions

Thermodynamics of biopolymer solutions, Osmotic pressure, Membrane equilibrium, Muscular contraction and energy generation in mechanochemical system.

UNIT – IV (12 Hrs)

Cell membrane and transport of ions :

Structure and functions of cell membrane, Ion transport through cell membrane, Irreversible thermodynamic treatment of membrane transport, Nerve conduction.

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UNIT – V **(12 Hrs)**

Bioploymers and their molecular weight

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

COURSE OUTCOMES:

On completion of the course the student will be able to;

- Learn on structure and functions of proteins, enzymes, DNA and RNA in living systems,
- Understand Standard free energy change in biochemical reactions.
- Properties and conformations of biomolecules like amino acids,proteins, nucleotides, nucleic acids as well as biomimetic systems like monolayers and bilayers are to be discussed.
- Understand statistical distribution end to end dimensions calculation of average dimensions for various chain structures.
- Acquire knowledge on various bioploymer interactions and thermodynamics of bioploymer solutions.
- Understand structure and function cell membrane and transport of ions and nerve conduction.
- Emphasis will also be given to understand the principles of major experimental techniques applied to understand these physical problems and their molecular weight.

Books Recommended:

1. Principles of Biochemistry by Lehninger, D.L. Nelson and M. Cox.
2. Bio-chemistry by Voet and Voet
3. Biothermodynamics by T.T. Edsall and H. Gutfreund, Wiley (NY)
4. BioPhysical Chemistry by J. Edsall and J. Wyman, Academic (NY)
5. Bioenergetics, A.L. Lehinger, Benjamin (NY)
6. Physical Chemistry: Principles and Applications in Biological Sciences (5th Edition), Authors: Ignacio Tinoco Jr., Kenneth Sauer, James C. Wang, Joseph D. Puglisi, Gerard Harbison, David Rovnyak

CH – 303 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

(Elective-I, Group-D)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

MACROMOLECULAR SYNTHESIS AND CHARACTERIZATIONS

Marks- 60 (Theory Examination)

MSCBU

Course Objectives:

- This course provides a foundation for basic and advanced aspects of polymer synthesis, characterisation, understanding of reaction mechanisms, and a qualitative molecular understanding of the resulting supra/macromolecular structures formed by these polymers.
- To gain knowledge knowledge on a variety of polymerization techniques such as polycondensation, ionic polymerization, a variety of controlled radical polymerization techniques, methathesis and insertion polymerization.
- The objective of the course is to introduce about different techniques available for structural characterization of macromolecules

UNIT - I **(12 Hrs)**

Ionic and Coordination Polymerization

Chemistry of Non-radical chain polymerization, Cationic polymerization, Mechanism & Kinetic with examples, Anionic polymerization, mechanism and Kinetics with example. Coordination polymerization (Zingler - Natta Catalyst), Steroregular polymerization, mechanism and kinetics of ring opeing polymerizatiion.

UNIT – II **(12 Hrs)**

Synthesis of Polymer

Bulk, Solution, Suspension, Emulsion, Precipitatiion Gas Phase, Solid State and interfacial methods of polymerization.

Polymerization and hydrogen transfer polymerization : Preparation Nylon 6.6 Poly (1.1. - undecanoamide). Poly (Decamethylene oxamide) Poly (Ethylene Terepthalate). Poly sulphone from Bio-Phenol - A & dichlorophenyl sulphone.

Thermal polymerization of styrene in Bulk, Emulsion polymerization of styrene with persulfate, suspension polymerization of styrene solution and emulsion polymerization of vinyl acetate, solution polymerization of Acrylamide.

UNIT – III **(12 Hrs)**

Ring - opening Polymerization

Fast polymerization of caporolactam to Nylon-6 with anion catalysts, low temperature polymerization of L-Piperidine to Nylon-5, polymerization of Ethylene oxide and Tetrahydrofuran and Preparation of linear polysilcons.

UNIT – IV **(12 Hrs)**

Non-classical routes to polymers-polymerization of Anhydrous formaldehyde to polyoxymethylene, solid state polymerization of Troioxane. Preparation of n-butylisolyanate, Diazomethane and Norbornlene.

Preparation of Pehnol-formaldehyde resin, Urea-formadehyde resin, Epoxy resin, Allyl resins.

UNIT – V **(12 Hrs)**

Characterisation of Polymers

UV-VIS Spectroscopy of Polymers, characterisation of polymer and copolymer by IR. NMR & EPR of polymers. X-ray diffraction and electron diffraction of polymers, composites. Thermal analysis of polymers by TG, DTG, DTA, DSC chromatograCH - Pyrolysis Gas chromatography and other chromatographic characterization.

COURSE OUTCOMES:

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

- Learn the mechanism of ionic and Coordination Polymerization. radical polymerization, methathesis and insertion polymerization.
- Describe different synthetic methods to prepare different types of Polymer.
- Acquire knowledge on Ring-opening Polymerization of different polymers.
- Understand UV-VIS spectroscopy, thermal methods and diffraction phenomenon in the characterization of polymers.

Books recommended:

1. Polymer Science, Gowariker, Viswanathan & Sreedhar
2. Polymer Scince, Premamaya Ghosh
3. Organic Polymer Chemistry, K.J. Saunders
4. Organic Chemistry of Macromolecules, A. Rayve
5. Polymer Chemistry, A.B. Seymour & C.E. Carraher
6. Experiments in Polymer Science, Edw and A. Collin & F.W. Billmeyer
7. Principle of Polymerization, Flory
8. Characterization of POlymer, N.M. Bikales
9. NMR of Polymers, I.Y. Slorium & A.N. Lyubimor
10. FT-IR Characterization of Polymer, H. Ishida

CH – 304 (5 Credits, 60 Hrs) **Marks – 100 (30+70)**

ORGANIC GENERAL PRACTICAL

Course Objectives:

- To carry out the separation of organic components from the binary mixture.
- To get the hands on training about the synthesis of simple organic molecules.
- To know and apply the separation and purification techniques for organic molecules.
- To understand the principles of estimation of keto and acetyl groups in an organic compound.
- Acquire skills in TLC, column chromatography, crystallization and preparation of dry solvents.

1. Analysis of Organic Compound

Separation and identification of components of a mixture of two organic compounds (solid-solid, solid-liquid, liquid-liquid).

2. Organic Synthesis (Single Step)

a) Preparatiion of p-bromoacetanilide.
b) Preparation of 3, 5 -dibromobenzoic acid.
c) p-bromo aniline preparation from aromatic electrophilic substitution reaction.
d) Preparation of p-chlorotolune.
e) Preparation of Methyl orange.
f) Preparation of Asprin
g) Preparation of Anthranilic acid.

3. Estimation

a) Estimation of Keto Group (>C=O)
b) Estimation of Acetyl group (-CO - CH_3)

4. Separation

Acetylation of Cholesterol and separation of cholesteryl acetate by column chromatograCH.

COURSE OUTCOMES:

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

- Able to determine the presence of functional groups in a given unknown organic compound
- Separation and qualitative analysis of two component mixtures of organic compounds: characterization of derivatives and identification of the components.
- .Able to carry out single stage synthesis of simple organic compounds and execute them in the laboratory.
- Acquire skills in different techniques such as melting point, distillation, TLC, column chromatography, crystallization and preparation of dry solvents.

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Books Recommended:

1. Vogel's Text Book of Practical Organic Chemistry, Furniss, S. B.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R. 5Th Ed.; Longman Scientific & technical, England, 1989.
2. Laboratory Manual of Organic Chemistry, Dey and Sitaraman, Allied Publishers, 1992.
3. Laboratory Manual of Organic Chemistry, Raj K Bansal, New Age International Publishers, 2008

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CH – 305 (3 Credits) **Total Marks- 100 (40+60)**

SWAYAM MOOCS

(Offered by NPTEL)

CH-AIT (3 Credits, 36 Hrs) **Marks- 50**

CERTIFICATE COURSE
ANALYTICAL INSTRUMENTATION TECHNIQUES

Course Objectives:

- To provide concepts on the several instrumentation techniques at the structural and chemical level which has become essential tools for chemical research.
- Understand and describe the fundamental principles behind the methods of characterization which are included in the course.
- To acquire skills in the use and selection of instrumental techniques for characterization of molecules, materials and application of these techniques to solving problems.
- To develop tools for analysis and methodologies that promotes multidisciplinary research for better understanding of composition-structure-properties correlation.

UNIT-I **(12 Hrs)**

General Introduction

Instrumentation methods of analysis, classification, advantage of instrumental methods, limitations, sensitivity and detection limit, precision and accuracy.

UNIT-1I **(12 Hrs)**

Fluorescence Spectroscopy

Basic principles, general instrumentation and applications of Fluorescence Spectrophotometer: relationship between excitation spectra and fluorescence spectra, factors affecting fluorescence emission.

UNIT-III **(12 Hrs)**

Atomic Absorption Spectroscopy

Basic principles, instrumentation and applications of Atomic Absorption Spectroscopy (AAS).

UNIT-IV **(12 Hrs)**

Thermal Methods of Analysis **[**

Basic principles, general instrumentation and applications: TGA (Thermo Gravimetric Analysis), DTA (Differential Thermal Analysis), DSC (Differential Scanning Calorimetry).

UNIT-V **(12 Hrs)**

Methods for Composition Analysis

Basic principles, general instrumentation and applications: Powder X-ray Diffraction (XRD), Particle size Analyzer (DLS) and Surface area Analyzer.

COURSE OUTCOMES:

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

- Understand basic concepts analytical instrumentation techniques and be able to appreciate limitations, sensitivity and detection limit, precision and accuracy in analytical methods.
- Explain the basic principles of spectroscopy and to interpret spectral data from one or more of these spectral techniques.
- Understand fundamental principles and applications of spectroscopic methods such as Fluorescence and Atomic Absorption spectroscopy.
- Explain the principles of operation and applications of analytical techniques such as thermal and diffraction methods such as X-ray for characterization of materials.
- Critically evaluate the potentials of all instrumental techniques and be able to quickly assimilate information.

Books Recommended:

1. Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
2. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
4. Principles of Instrumental Analysis – Skoog and Leary, Saunders College Publ. IV Edition, 1992
5. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
6. Principles and Practice of Analytical Chemistry, F.A. Fifield & Dacid Kealy, Blackwell Publishing, 5thEdn, 2000.

SEMESTER – IV

CH – 401 (5 Credit, 60 hour) **Total Marks- 100 (40+60)**

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

SPECTROSCOPY-II

Marks- 60 (Theory Examination)

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Course objectives:

- The main objective of this course is to teach fundamental principles of various spectroscopic techniques used for structural elucidation of organic compounds.
- Focus will be given on problem solving approach for structural elucidation.

UNIT – I **(12 Hrs)**

(a) Vibrational Rotational Spectroscopy.

Group vibration concept and its limitations, Use of symmetry arguments to determine the number of active infrared and Raman lines. Applications of infrared and Raman spectroscopy for determination of inorganic structures.

(b) **Mossbauer Spectroscopy.**

Basic principles, interpretation of isomeric shift, electronic quadrupole intractions, spectrum display. magnetic interaction, mossbaur emmission spectroscopy, application of Mossbauer Spectroscopy to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds - nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms.

UNIT - II **(12 Hrs)**

Ultraviolet and Visible Spectroscopy

Electronic transitions (185- 800 mm.) Beer-Lambert Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser- Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds.

UNIT-III **(12 Hrs)**

Infrared Spectroscopy

Instrument and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols aryl amines. Detailed study of vibrational frequencies of carbonyl compounds (Ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance.

UNIT – IV **(12 Hrs)**

Nuclear Magnetic Resonance Spectroscopy

General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (Aliphatic, olefinic, enols, carboxylic acids, amines, amides &

mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindred rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE), Resonance of other nuclei-F, P

UNIT – V **(12 Hrs)**

Mass Spectrometry

Introduction ion production - EI, CI, FD and FAB, factors affecting fragmentation, ion analysis,ion abundance. Mass spectral fragmentation of organic compounds,common functional groups, molecular ion peak, metastable peak, Mc Lafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

COURSE OUTCOMES:

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

- Learn the principles of Infrared and Raman spectroscopy, correlate with the molecular modes of vibration and apply the rules to interpret the spectra of organic molecules.
- Understand the basic principles of Mossbauer spectroscopy and apply to elucidate the structure of inorganic molecules.
- Learn the concept and rules of electronic transitions in organic molecules and their correlation with UV absorption spectroscopy.
- Describe the applications of UV-Visible spectroscopy in the identification of conjugation in organic compounds.
- Understand the basic principles of NMR and able to analyze the ^{1}H NMR data of simple organic compounds.
- Analyze and apply the rules of Mass spectroscopy for the fragmentation pattern in different types of organic functional groups.
- Analyze and identify simple organic molecules by using UV, IR, Mass and ^{1}H NMR data.

Books Recommended:

1. Structural Methods in Inorganic Chemistry, E.A.V. Wbsworth, D.W.H. Rankin and S. Cradock, ELBS.

2. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.

3. Symmetry in bonding and spectra: An Introduction by B.E Douglas, Academic Press.

4. Fundamental of Molecular Spectroscopy, C.N.Banwell & Elaine M. McCASH, Fourth edition (2017)

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5. Spectrometric Identification of Compounds, R. M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
6. Speectroscopy of Organic Compounds, P. S. Kalsi, New Age International Publishers, 2020, 8 th Ed
7. Spectroscopy, H Kaur, Pragati Prakashan, 2017
8. Introduction to Spectroscopy, Donald J Pavia, Gary M. Lampman & George S. Kriz Cengage Learning India Private Limited; 5th edition (2015)
9. Organic spectroscopy by William Kemp 3rd edn W.H.Freeman & Co, 1991
10. Spectroscopy Methods in Organic Chemistry, D. H. Williams, I. Fleming, Tata McGraw.

CH – 402 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**
(Elective-II, Group-A)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

ORGANIC SYNTHESIS - II
Marks- 60 (Theory Examination)

Course Objectives:

- To learn the principles of protecting group chemistry and retrosynthetic approach towards organic synthesis molecules.
- To find the application of retrosynthesis for synthesis of important complex molecules

UNIT – I (12 Hrs)

Disconnection approach

An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversion, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reaction andamine synthesis.

UNIT – II (12 Hrs)

Protecting groups

Principle of protection and deprotection of alcohol, amine, carbonyl and carboxyl groups.

UNIT – III (12 Hrs)

One group C-C disconnections

Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

Two group C-C disconnections

Diels-Alder reaction, 1,3-difunctionalised compounds, , -unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds, Micheal addition and Robinson annulation.

UNIT – IV **(12 Hrs)**

Ring synthesis

Balwdin's rules for ring closure, Saturated heterocycles, Synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis.

UNIT – V **(12 Hrs)**

Synthesis of some complex molecules

Application of the above in the synthesis of following compounds: Camphor, Longifoline, Reserpine, Vitamin D, Aphidicolin and Fredericamycin A.

COURSE OUTCOMES:

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

- Compile and demonstrate knowledge on retrosynthesis and various terminologies, retro synthesis of simple molecules-alcohols, alkenes and dicarbonyl compounds, formation of C-C bond using different coupling reactions.
- Analyze and formulate the chemistry of protection and de-protection strategies and functional group inter conversion.
- Understand the principles of ring synthesis involving saturated and aromatic heterocycles.
- Retrosynthetic analysis and synthesis of some complex molecules.

Books Recommended:

1. Organic Synthesis: The Disconnection Approach: S. Warren, John Wiley & Sons, 1984
2. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, CRC publication
3. Organic Synthesis, Jagdamba Singh and L D S Yadav, Pragati Prakashan, 2015.
4. Modern Organic Synthesis: An Introduction: George S. Zweifel, Michael H. Nantz and Peter Somfai, Wiley publications
5. Organic Synthesis: Strategy and Control: Paul Wyatt, Stuart Warren, Wiley publication

CH – 402 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**

(Elective-II, Group-B)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

ORGANO-TRANSITION METAL CHEMISTRY

Marks- 60 (Theory Examination)

Course Objectives:

- To understand fundamentals of organometallic chemistry, nature of bonding, and chemical properties of commonly encountered organometallic compounds.
- To learn stepwise mechanism of insertion of metal into organic molecules and elimination by different pathways.
- Fluxionality and dynamics in organometallic chemistry will be elaborated.
- Students will learn about selected applications of organometallic catalysis.

UNIT – I (12 Hrs)

Alkyls and Aryls of Transition Metals

Types, routes of synthesis, stability and decomposition pathways, organo-copper in organic synthesis.

Transition Metal Compounds with Bonds to Hydrogen

Transition metal compounds with bonds to hydrogen

UNIT-II (12 Hrs)

Compounds of Transition Metal- Carbon Multiple Bonds

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

UNIT – III (12 Hrs)

Transition Metal π -Complexes

Transition Metal -complexes with usaturated 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 – IV (12 Hrs)

Fluxional Organometallic Compounds

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

Organometallic Reagents - Synthesis, structure of organometallic reagents of transition metals such as Pd, Rh, Ni, and Fe and their applications in organic synthesis.

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UNIT – V **(12 Hrs)**

Organometallic reactions and catalysis

Fundamental reactions: Insertion (CO and SO_2) and elimination reactions, oxidative and reductive eliminations, activation of C-H bond.

Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, hydro carbonylation of olefins (oxo reaction).

COURSE OUTCOMES:

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

- Learn about synthesis, stability and decomposition pathways of transition metal alkyl and aryl complexes.
- Learn about preparation, properties, nature of bonding, structural features and reactions relating to nucleophilic and electrophilic attack on ligands of alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes.
- Acquire knowledge on fluxionality and dynamic equilibria in compounds such as η^2 - olefin, η^3 - allyl and dienyl complexes.
- Synthesis, structure of organometallic reagents of transition metals such as Pd, Rh, Ni, and Fe and their applications in organic synthesis.
- Understand fundamental reactions like insertion (CO and SO_2), elimination reactions, oxidative and reductive eliminations.
- Learn about stoichiometric reactions for catalysis, homogeneous catalytic isomerisation, hydrogenation of olefines, Zeigler-Natta polymerization of olefins, hydrocarbonylation of olefins (oxo reaction).

Books Recommended:

1. Principles and Application of Organo transition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley
3. Metallo-organic Chemistry, A.J. Pearson, Wiley
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.
5. Concepts and Models of Inorganic Chemistry by B.E. Douglas, D.H.McDaniel and J.J Alxendar, John Wiley, 1993 3rd Ed.
6. Reaction mechanism in Inorganic Chemistry by R.R.Jordan Oxford Univ. Press, 1998 2nd ED.
7. Advanced Inorganic Chemistry by F.A. cotton and G.W. Wilkison.John-Wiley & Sons, 1988, 5th Ed.

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CH – 402 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**
(Elective-II, Group-C)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

SURFACE CHEMISTRY

Marks- 60 (Theory Examination)

Course Objectives:

- To introduce the basic concepts of surface and interfacial chemistry.
- To learn chemical processes that occur at solid-liquid, solid-gas and liquid-gas interfaces.
- To understand spectroscopy and microscopy methods to study the interfacial phenomena

UNIT – I **(12 Hrs)**

Adsorption

Surface tension, capillary action, pressure difference across curved surface, vapour pressure of droplets, Gibbs adsorption isotherm, estimation of surface area (BET) equations, catalytic activity at surfaces.

UNIT – II **(12 Hrs)**

Micelles

Surface active agents, classification of surface active agents, micellization, hydrophobic interactions, critical micellar concentration (CMC) factors affection CMC, Solubilization, micromulsion and reverse micelles.

UNIT-III **(12 Hrs)**

Macromolecules

Macromolecules: Polymer-definition, types of polymer, electrically conducting, fire resistant, liquid crystal polymer. Molecular mass, number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering), sedimentation, chain configuration of macromolecules, calculation of average dimension of various chain structures.

UNIT-IV **(12 Hrs)**

Surface reactions: General aspects, co-adsorption, poisoning and promotion effects, model reactions, Examples of surface reactions, detection of adsorbates on surfaces. High pressure catalytic reactions on single crystal surfaces: examples - CO oxidation and methanation, ammonia synthesis, epoxidation reactions.

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UNIT-V **(12 Hrs)**

Techniques of Surface Investigation. Electron diffraction, scanning tunneling microscopy (STM), High resolution electron energy loss spectroscopy (HREELS), X-ray and Ultravoilet photoelectron Spectroscopy (XPS and UPS). Inverse photo emission, ion scattering (LEIS, SIMS), Auger electron spectroscopy (AES), Thermal desorption and work function measurements-Basic principles and applications.

COURSE OUTCOMES:

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

- Understand concepts of solid-liquid, solid-gas, liquid-gas interfaces.
- Apply fundamental principles of chemistry to chemical processes occurring at interfaces.
- Apply spectroscopic methods to study interfaces and interfacial phenomena.

.Books Recommended:

1. Adsorption and Catalysis, by D.K. Chakraborty
2. Solid state chemistry and its application, by A.R. West
3. Physical chemistry, by G.M. Barrow.
4. Solid state chemistry, by H.V. Keer

CH – 402 (5 Credits, 60 Hrs) **Total Marks- 100 (40+60)**
(Elective-II, Group-D)

***Internal Assessment Examination (40 Marks) = 20 (Written) + 10 (Quiz) + 10 (Assignment/Seminar Presentation)**

PHYSICAL CHEMISTRY OF POLYMERS

Marks- 60 (Theory Examination)

Course Objectives:

- To understand thermodynamic functions of polymer mixture.
- To identify and describe different polymer structures and understand how the chemical structure affects the properties of a polymer in solution and in the solid state.
- To evaluate polymer morphology, phase transitions, and viscoelastic properties in both solid and solution states.
- Identify and describe the roles of specialty polymers, additives and nanofillers in advanced polymer application.

UNIT – I **(12 Hrs)**

Thermodynamic of Polymer Mixture

Partial molar function, ideal and non-ideal solution, enthalpy and entropy of mixing & florykingbaurn theory. Free energy of mixing of a polymer with a solvent - Thermodynamics of swelling of cross-linked polymers.

UNIT – II **(12 Hrs)**

Morphology and Crystallinity

Cofiguraion of Polymer chain, Crystal structure of polymers, Morphology of Polymer single crystals structure of polymers crystallised from melt. Crystalizatiion. Orientation and drawing. Amorphous Polymers.

UNIT – III **(12 Hrs)**

Rheology and Mechanical Properties of Polymers

Viscous flow, viscoelasticity, the glassy state and the glass transition. Mechanical properties of crystalline polymers. Statistical behavious of polymer moleculars. Random fight - chain model freely rotating chain model, Hindered rotation model. Rotationl Isomeric state model.

UNIT - IV **(12 Hrs)**

Technology of Polymers

Additives of Polymers: Filleers and Rainforcement Plasticisers, Antioxidants, Stabilsers, Crosslinking agents, Activators, accelerations, Lubricating agents, antistatic agents colourants.

UNIT – V **(12 Hrs)**

Fabrication Film casting, casting of casting of articles in models, compression and transfer molding. Thermoforming and welding, calendering, multipolymer systems & composites. Laminates, Foam, Coatings, Adhesives, Pressure sensitive Adhesive.

COURSE OUTCOMES:

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

- Interpret thermodynamic functions and its physical significance.
- Predict polymer properties such as mechanical and its rheology based on their structure.
- Understand phase transition and accompanying structural change.
- Understand how polymer additives enhance material properties and contribute to construction projects, making buildings stronger and more durable.

Books Recommended:

1. Introduction to Polymer Science and Technology, H.S. Kaufman & J.J. Falcetta.
2. Viscoelastic properties of the Polymers, J.D. Ferry
3. Physical Chemistry of Polymer, A. Tagor
4. Statistical Mechanis of Polymers, P.J. Flory

5. Text Book of Polymer Science and Engineering, Anil Kumar Gupta.
6. Plastic Materials, J.A. Brydson.
7. Essential Fiber Chemistry, M.E. Cartel
8. Textile Fibers, J. Peters.

CH - 403 (5 Credits, 60 Hrs) **Marks-100 (30+70)**

PRACTICAL (Elective, Group -A)

Course Objectives:

- To separate and analyse the component of a binary mixtures.
- To get hands on training in the synthesis of simple organic molecules.
- To know the principles of separation and purification techniques for organic molecules.
- Understand principles of quantitative estimation of functional group in a molecule.
- Understanding of spectrophotometric estimation of aminoacids.

1. Qualitative analysis
Separation and identification of Organic Compound of binary mixture (one liquid and one solid)

2. Organic synthesis (single step)

a) Preparation of Salicylaldehyde.
b) Preparation of quinoline
c) Cannizzaro reaction : 4 - chlorobenzaldehyde as substrate.
d) Aldol condensation : Dibenzal acetone from benzaldehyde.

3. Organic synthesis (multi step)
Benzene Nitrobenzene Aniline Phenol

4. Quantitative analysis
Determination of the percentage or number of hydroxyl groups in an organic compunds by acetylation method.

5. Spectrophotometric estimation
Amino Acids.

COURSE OUTCOMES:

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

- Separate and analyse the component of a binary mixtures.
- Synthesize simple organic molecules.
- Understand separation and purification techniques for organic molecules.
- Understand principles of quantitative estimation of functional group in a molecule.

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- Spectrophotometric estimation of aminoacids.

Books Recommended:

1. Vogel's Text Book of Practical Organic Chemistry, Furniss, S. B.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R. 5Th Ed.; Longman Scientific & technical, England, 1989.
2. Laboratory Manual of Organic Chemistry, Dey and Sitaraman, Allied Publishers, 1992.
3. Laboratory Manual of Organic Chemistry, Raj K Bansal, New Age International Publishers, 2008

CH-403 (5 Credit, 60 Hrs) **Marks-100 (30+70)**

PRACTICAL (Elective, Group-B)

Course Objectives:

- To have hands-on experience/practical knowledge in the preparation and characterization simple coordination complexes.
- Understand and apply the principles of ion exchange methods of separation and estimation of mixtures of cations.
- To understand the principles of spectrophotometry in the determination of composition and acid dissociation constant of complexes.
- To learn the estimation of different metal ions and anions quantitatively in mixtures and alloys.
- To apply principles of potentiometry to determine acid dissociation constants of simple coordinated ligands.

1. Preparation and Characterization

Preparation of simple complex compounds of Cr(III)/Co(III). Estimation of the metal content and other components of the complexes such as:

Cis - $K[Cr(C_2O_4)_2(H_2O)_2]$

Tranns- $[Co(en)_2Cl_2]Cl$

2. Ion exchange methods of separation and estimation

(i) Separation of mixtures of cations (Co-Ni, Fe-Zn, Zn-Mg, Cd-Zn) by ion exchange method and estimation of the components after separation.

(ii) Determination of metal content and free acid in $FeCl_3/CuCl_2$ solution.

3. Spectrophotometry

(i) Determination of composition of a complex compound in solution by Job's continuous variation method.

(ii) Determination of acid dissociation constant of pentaammine(salicylato)-cobalt(III) complex.

4. Quantitative analysis

Analysis of solder and brass.

5. Potentiometry

Determination of acid dissociation constants of simple coordinated ligands by pH metry.

COURSE OUTCOMES

After completion of this course student will be able to:

- Gather experience on the synthesis of coordination complexes
- Prepare complexes of Cr (III)/Co(III)and estimate the amount of constituents.
- Lear separation of mixtures of cations and determine the amount of free acid and metal content in $FeCl_3$ /$CuSO_4$solution by ion exchange methods.
- Determine the composition of a complex compound in solution by job's continuous variation method.
- Determination of acid dissociation constant of pentaammine(salicylato)-cobalt(III) complex.
- Estimate different metal ions and anions quantitatively in mixtures and alloys

Books Recommended:

1. A Text book of Qualitative Analysis, A. I. Vogel
2. A Text book of Quantitative Analysis, A. I. Vogel
3. Inorganic synthesis, Vol. 1 -20

CH – 403 (5 Credits, 60 Hrs) **Marks-100 (30+70)**

PRACTICAL (Elective, Group -C)

1. Spectrophotometry

Verification of additivity law.
Characterization of complexes by spectroscopic data.
Estimation of metal ions by spectrophotometric titration.
To determine of pH of an indicator

2. Potentiometery

To determine first and second ionization constant of multi basic acid.
To determine the standard electrode potential of Ferrous-Ferric system.

3. Conductometry

To determine hydrolysis constant of aniline hydrochloride.
To determine solubility and solubility product of a sparingly soluble salt.
Verification of Debye-Huckel and Onsager's limiting law.

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4. **Surface / phase**
   To study the adsorption of acetic acid on activated charcoal.
   To determine the demerization constant of benzoic acid in benzene medium by partition method.
5. **Solid state**
   XRD of simple solids (NaCl, CsCl, Graphite etc. Spectral data analysis only)
6. **Viscometery**
   Determination of molecular weight by Ubbelhood Viscometer.

CH - 403(5 Credits, 60 hrs) **Marks-100 (30+70)**

PRACTICAL (Elective, Group -D)

1. Determination of Molecular weight of given Polymer by Ubblehode Viscometer.
2. Determination of molecular weight of a given polymer by end group analysis.
3. Chemical Testing of polymers.
4. Determination of Tg of a given polymer by Thermogravimetric analysis.
5. Polymerisation of vinyl monomer by free radical method and characterization.
6. Polymerization of PMMA by emulsion polymerisation method.

CH-404 (5 Credit, 60 Hrs) **Marks-100**

PROJECT WORK

The project work will consist of experimental / review work under direct supervision of faculty members.

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