



**NEP PG CURRICULUM
M.Sc. CHEMISTRY PROGRAMME**

SUBJECT CODE = CHE

FOR POSTGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI



Implemented w.e.f.
Academic Session 2025-26 Onwards

**Members of NEP Implementation and Monitoring Committee of the Ranchi University,
Ranchi**

The Curriculum of M.Sc. Chemistry is approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the H.O.D. of concerned departments, will be offered to the Students of 1 year & 2 years PG. Chemistry Programme FYUGP. It is implemented from the 1st Semester of the 2025-26 session onwards.

Member Secretary

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HIGHLIGHTS OF NEP PG CURRICULUM

CREDIT OF COURSES

The term ‘credit’ refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ Lectures or two hours of laboratory /practical work will be assigned per class/interaction.

One credit for Theory = 15 Hours of Teaching

One credit for Practicum = 30 Hours of Practical work

One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:

Hours (L) – Classroom Hours of one hour duration.

Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration

Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.

Internship – For the Exit option after 1st year of the 2-year P.G. Programme for the award of P.G. Diploma, Level 6.5, Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

PG CURRICULUM

1. The PG Curriculum will be either of 1-year duration for students who studied the four-year UG Programme (FYUGP) or a 2-year duration for students who studied a three-year UG programme from a CBCS/LOC/FYUGP Curriculum.
2. There is a flexible mode in the PG programme offered to the students of Ranchi University, Ranchi. The total credit for any semester will be 20 credits.
3. **Two-year PG curriculum:** The First year of the PG curriculum offers coursework only. There will be 3 courses at level 400 and 2 courses at level 500 in the first and the second semesters of any 2-year PG programme.
4. **One-year PG curriculum:** The Courses in the 1-year PG programme and the second year of the 2-year PG programme are the same.
 - a. **Course work only:** There will be 5 courses at level 500 of 4 credits each in every semester for the coursework offered in the programme.
 - b. **Course work and Research:** There will be 5 courses at the level 500 bearing 4 credits each in the first semester of a 1-year PG or in the third semester of a 2-year PG. There will be Research work offered in the next semester for this mode offered in the programme. The eligibility for this mode is available in the NEP PG curriculum of Ranchi University, Ranchi.
 - c. **Research work only:** The eligible student will be offered this mode to conduct extensive research under the supervision of a guide. Each semester will be equivalent to 20 credits. The selection of a candidate for the research mode will depend upon the eligibility of the student, availability of the guide and seat in the department/institution of Ranchi University, Ranchi.

PROMOTION CRITERIA

Two Years Post-graduation programme having coursework only:

- i. Each course shall be of **100 marks** having two components: **30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College and 70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University.**
- ii. The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Written Assignment/ Seminar presentation and 05 for overall performance of a student including regularity in the class room lectures and other activities of the Department/College.

- iii. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
- iv. There shall be two written internal examinations, each of 1 hour duration and each of 20 marks, in a semester out of which the '**Better One out of Two**' shall be taken for computation of marks under SIA.
- v. If a student failed to secure pass marks in Mid Semester, he/she has to reappear in Mid & End Semester Examinations.
- vi. In case a student is fail to secure pass marks in End Semester Examination, then he/she has to appear only in End Semester Examination of following Sessions within period of Upper Limit of Four Years and the Marks of Mid Semester will be carried for the preparation of result.
- vii. Students' final marks and the result will be based on the marks obtained in Mid Semester and End Semester Examination organized taken together.
- viii. The pass marks in the programme will be 45% of the total marks obtained in each Core/ Elective/ Other Courses offered.
- ix. In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE and a minimum of 17 marks is to be secured in the SIA** to clear the course. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.
- x. Every candidate seeking to appear in the ESUE shall be issued an Admit Card by the University. **No candidate will be permitted to appear in the examination without a valid admit card.**
- xi. A candidate shall be permitted to proceed in next Semester (2nd, 3rd and 4th) **provided he/she has passed at least in 3 courses out of 5 courses** in the respective semester in theory and practical/ project courses taken together.
- xii. A student will have to clear all his papers within maximum of Four Years of duration to qualify for the degree.

However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

VALUE ADDED COURSES

- 1. The Value added course will be of **2 credits** to be covered during the first semester.
- 2. There will be objective-type questions asked in the End Semester University Examination (ESUE).
- 3. There will be OMR-based examination and the correct answer is to be marked by a black ballpoint pen only on the OMR sheet provided by the University.
- 4. For **50 Marks Examination** the student will be provided **Two hours** for marking their responses.
- 5. Students are not allowed to choose or repeat courses already undergone at the undergraduate level in the proposed major and minor streams.
- 6. The performance in this course will not influence the SGPA or CGPA of the PG Programme where the student is registered to obtain the Master's Degree. **However, it will be mandatory to secure minimum pass marks in the course before exit from the PG Programme.**
- 7. If the student fails to secure the minimum pass marks in the Value added course in the first semester, he may appear in the examination of the said course with the following batch of the next session.
- 8. The student may appear in the examination of the said course further if could not clear the course in the following attempt, subject to the date of validation of the Registration.

The Regulations related to any concern not mentioned above shall be guided by the existing Regulations of the PG Curriculum of Ranchi University, Ranchi.

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COURSE STRUCTURE FOR PG 'PG DIPLOMA/ COURSEWORK ONLY/ COURSEWORK WITH RESEARCH/ RESEARCH ONLY '

Table 1: Credit Framework for One Year Postgraduate Programme (PG) [Total Credits = 80]

Academic Level	Level of Courses	Semester	Coursework Level 400	Coursework Level 500	Research Preparedness	Research thesis/ Project/ Patent	Total Credits
YEAR 1							
Level 6.5	Coursework	I	4+4+4	4+4	---	---	20
		II	4+4+4	4+4	---	---	20
YEAR 2: Exit Point: Having Internship of 4 credits Exit allowed with PG Diploma Certificate							
Level 6.5	Coursework	III	---	4+4+4+4+4	---	---	20
		IV	---	4+4+4+4+4	---	---	20
OR							
Level 6.5	Coursework + Research	III	---	4+4+4+4+4	---	---	20
		IV	---	---	20		20
OR							
Level 6.5	Research	III	---	---	20	---	20
		IV	---	---	---	20	20
Total credits of P.G. Programme = 80							

Note: Having Internship of 4 credits 'Exit' is allowed with awarding the PG Diploma Certificate.

Implemented from Academic Session 2025-26 & Onwards

AIMS OF MASTER'S DEGREE PROGRAMME IN CHEMISTRY**The aim of Master's degree programme in Chemistry is intended to provide:**

The aim of the Master's degree programme in Chemistry is to provide advanced and comprehensive knowledge of advanced chemistry, integrating basic understandings of tools and techniques of chemistry including analytical chemistry and spectroscopic identification of compounds. It deals with various spectroscopic techniques exploring the theoretical basis of the development of the techniques and the application in the field of analysis and establishing the identity of unknown materials.

The programme is designed to develop a deep understanding of Research Methodology, awareness towards the Environmental issues, the interrelationships among physical, organic and inorganic chemistry and their adaptations to diverse environments. The course in Indian Knowledge System (IKS) is designed to make student known about the glorious past of Indian Chemical Practices and their relevance in modern contemporary world. Biochemistry explores the importance of metal and metal ions in the life processes. Student will come to know the effectivity of enzymes as biocatalyst to support the biological processes. The material chemistry will uplift the knowledge to the cutting edge development in material science.

Through laboratory work, field studies, and research projects, the programme fosters scientific inquiry, critical thinking, and analytical skills. A key objective is to prepare students for careers in research, education, environmental management, and related applied sectors, while also enabling them to pursue higher studies and contribute to addressing contemporary chemical and environmental challenges. Ultimately, the programme aims to nurture professionals with scientific competence, ethical responsibility, and a commitment to the sustainable management of chemical resources.

PROGRAMME LEARNING OUTCOMES

The broad aims of Master's degree programme in Chemistry are:

- (i) **Core competency:** Students will acquire core competency in the subject Chemistry, and in specialized knowledge in one of its core area viz. Physical, Organic & Organic Chemistry.
- (ii) Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, and Biochemistry.
- (iii) Students will be able to understand and use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.
- (iv) The students will be able to understand the characterization of materials.
- (v) Students will be able to understand the basic principles of equipment, instruments used in the chemistry laboratory.
- (vi) Students will be able to understand and demonstrate the experimental techniques and methods of their area of specialization in Chemistry.
- (vii) **Disciplinary knowledge and skill:** A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be capable of using of advanced instruments and related software for in-depth characterization of materials/chemical analysis and separation technology.
- (viii) **Skilled communicator:** The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.
- (ix) **Critical thinker and problem solver:** The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.
- (x) Sense of inquiry: It is expected that the course curriculum will develop an inquisitive characteristic among the students through appropriate questions, planning and reporting experimental investigation.
- (xi) **Team player:** The course curriculum has been designed to provide an opportunity to act as a team player by contributing in laboratory, field-based situations and industry.
- (xii) **Skilled project manager:** The course curriculum has been designed in such a manner as to enable a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.
- (xiii) **Digitally literate:** The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of chemical simulation software and related computational work.
- (xiv) **Ethical awareness/reasoning:** A graduate student is required to understand and develop ethical awareness/reasoning, which the course curriculum adequately provides.

Lifelong learner: The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT techniques and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunities.

The Courses in One Year P.G. Programme and in the Second year of Two years P.G. Programme are Common.

Table 2: Semester-wise Course Code and Credit Points

Sem	Core, AE/ GE/ DC/ EC & Compulsory FC Courses				Examination Structure		
	Paper	Paper Code	Credit	Name of Paper	Mid Semester Evaluation (F.M.)	End Semester Evaluation (F.M.)	End Semester Practical/ Viva (F.M.)
I	Foundation Course	FCCHE101	4	Foundation Chemistry	30	70	----
	Core Course	CCCHE102	4	Molecular Spectroscopy	30	70	----
	Core Course	CCCHE103	4	Research Methodology	30	70	----
	Core Course	CCCHE104	4	Photochemistry	30	70	----
	Practicals on Core	CPCHE105	4	Practical-I	----	----	100
II	Core Course	CCCHE201	4	Quantum Chemistry & Nuclear Chemistry	30	70	----
	Core Course	CCCHE202	4	Mechanism in Organic Chemistry	30	70	----
	Core Course	CCCHE203	4	Group Theory & Transition Elements	30	70	----
	Core Course	CCCHE204	4	Environmental Chemistry	30	70	----
	Practicals on Core	CPCHE205	4	Practical-II	----	----	100
III	Core Course	ECCHE301	4	Indian Knowledge System & Metallurgy	30	70	----
	Skill Enhancement Course	CCCHE302	4	Bio-Chemistry	30	70	----
	Core Course	CCCHE303	4	Applications of Spectroscopy	30	70	----
	Core Course	CCCHE304	4	Analytical Chemistry	30	70	----
	Practicals on Core	CPCHE305	4	Practical-III	----	----	100
IV	Elective	ECCHE401	4	A. Inorganic-1A B. Organic-1B C. Physical-1C	30	70	----
	Elective	ECCHE402	4	A. Inorganic-2A B. Organic-2B D. Physical-2C	30	70	----
	Core Course	CCCHE403	4	Material Chemistry	30	70	----
	Practicals on Elective	EPCHE404	4	A. Inorganic Practical-4A B. Organic Practical-4B C. Physical Practical-4C	----	----	100
	PROJECT	PRCHE405	4	Dissertation/ Project Work/ Teaching Aptitude	----	----	100

*** Either One Internship of 4 credits or Two Internships of 2 credits each is required before opting for the 'Exit' option after the First year of the P.G. Programme.**

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There Marks Weightage of a Course: Each non-practical/non-project course shall be of **100 marks** having two components: **70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University, and, 30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College.**

The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Written Assignment/ Seminar presentation and 05 for overall performance of a student including regularity in the class room Lectures and other activities of the Department/College. There shall be two written internal examinations, each of 1-hour duration and each of 20 marks, in a semester out of which the '**Better One out of Two**' shall be taken for computation of marks under SIA.

In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE and a minimum of 17 marks is to be secured in the SIA to clear the course.** In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

A. (SIE 20+5=25 marks):

There will be a uniform pattern of questions for mid-semester examinations in all the courses and of all the programmes. There will be **two** groups of questions in 20 marks written examinations. **Group A is compulsory** and will contain five questions of **very short answer type** consisting of 1 mark each. **Group B will contain descriptive type** five questions of five marks each, out of which any three are to be answered. Department may conduct Sessional Internal Examinations in other format as per needs of the course.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESUE):

A. (ESUE 70 marks):

There will be a uniform pattern of questions for all the courses and all the programmes. There will be **two** groups of questions. **Group A is compulsory** and will contain two questions. **Question No.1 will be very short-answer type** consisting of five questions of 1 mark each. **Question No.2 will be a short-answer type** of 5 marks. **Group B will contain descriptive type** six questions of fifteen marks each, out of which any four are to be answered. The questions will be so framed that examinee could answer them within the stipulated time.

[Note: There may be subdivisions in each question asked in Theory Examinations]

B. (ESUE 100 marks):

Practical/ Project courses would also be of 100 marks but there **shall be no internal written examinations** of the type specified above. The total 100 marks will have two components: **70 marks for the practical ESUE and 20 marks for the Viva-voce examination** conducted during the ESUE to assess the applied and practical understanding of the student.

The written component of the project (**Project Report**) shall be of **70 marks and 20 marks will be for the Viva-voce examination** jointly conducted by an external examiner, appointed by the University, and the internal supervisor/guide.

10 marks will be assigned on the cumulative assessment of the examinee during the semester and will be awarded by the department/faculty concerned.

FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS**Question format for 20 Marks:**

F.M. =20	Subject/ Code Time=1Hr.	Exam Year
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 1 out of 2 subjective/ descriptive questions given in Group B . iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
	Group A	
1.	i.	[5x1=5]
	ii.	
	iii.	
	iv.	
	v.	
2.	.....	[5]
	Group B	
3.	.....	[10]
4.	.....	[10]
Note: There may be subdivisions in each question asked in Theory Examination.		

Question format for 70 Marks:

F.M. =70	Subject/ Code Time=3HrS.	Exam Year
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 4 out of 6 subjective/ descriptive questions given in Group B . iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
	Group A	
1.	i.	[5x1=5]
	ii.	
	iii.	
	iv.	
	v.	
2.	.....	[5]
	Group B	
3.	.....	[15]
4.	.....	[15]
5.	.....	[15]
6.	.....	[15]
7.	.....	[15]
8.	.....	[15]
Note: There may be subdivisions in each question asked in Theory Examination.		

SEMESTER I**I. FOUNDATION COURSE
FOUNDATION CHEMISTRY**

[FCCHE101]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner will be able to understand:

1. Reaction Mechanism and factors related to Structure and Reactivity in inorganic reactions.
2. Different types of substitution reactions of complexes.
3. Electronic spectra of inorganic molecules.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Explain the labile and inert behaviour of complexes.
2. Explain the kinetic application of valence bond and crystal field theories
3. Appreciate one-electron transfer reactions.

Course Content:**UNIT I: Metal-Ligand Bonding**

(05 Lectures)

Limitations of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes, p-bonding and molecular orbital theory.

Stereochemistry and Bonding in Main Group Compounds

(05 Lectures)

VSEPR, Walsh diagrams (tri-atomic molecules of type AH_2), $d\pi-p\pi$ bonds, Bent rule and energetic of hybridization, some simple reactions of covalently bonded molecules, Atomic Inversion, Berry Pseudorotation.

UNIT II: Metal-Ligand Equilibria in Solution

(05 Lectures)

Step-wise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.

UNIT III: Acids, Bases, Electrophiles, Nucleophiles and Catalysis

(09 Lectures)

Acid-base dissociation. Electronic and structural effects, acidity and basicity. Acidity functions and their applications. Hard and soft acids and bases. Nucleophilicity scales. Nucleofugacity. The α -effect. Ambivalent nucleophiles. Acid-base catalysis-specific and general catalysis. Bronsted catalysis. Nucleophilic and electrophilic catalysis. Catalysis by non-covalent: binding-micellar catalysis.

UNIT IV: Nature of Bonding in Organic Molecules

(10 Lectures)

Delocalized chemical bonding: conjugation, cross-conjugation, resonance, hyperconjugation, bonding in fullerenes, tautomerism.

Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of 7-molecular orbitals, annulenes, anti-aromaticity, Y-aromaticity, homo-aromaticity, PMO approach.

Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

UNIT V: Stereochemistry

(10 Lectures)

Cycloalkanes and stability, Baeyer strain theory. Conformation analysis and Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms. Conformational analysis of decalins, effect of conformation on reactivity, conformation of sugars, and steric strain due to unavoidable crowding.

Methods of resolution of chiral compounds, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.

Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

UNIT VI: A Mathematical Approach to MO Theory

(6 Lectures)

Valence bond and Molecular orbital approaches, LCAO-MO treatment of H_2 , H_2^+ , bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their

limitations. Average and most probable distances of the electron from the nucleus. Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Huckel theory.

UNIT VII: Unifying Principles**(10 Lectures)**

Electromagnetic radiation, interaction of electromagnetic radiation with matter: absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, results of the time-dependent perturbation theory, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels.

Books Suggested:

1. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
2. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
3. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
4. Quantum Chemistry, Ira N. Levine, Prentice Hall.
5. Chemical Applications of Group Theory, F. A. Cotton.
6. Physical Methods in Chemistry, R.S. Drago, Saunders College.
7. Introduction to Molecular Spectroscopy, Q.M. Barrow, McGraw Hill.

II. CORE COURSE
MOLECULAR SPECTROSCOPY

[CCCHE102]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

This course is designed:

1. To expose the students to the basic principles of spectroscopic theory.
2. Application of spectroscopic techniques in organic chemistry. Interaction of electromagnetic radiations and matter.
3. Applications of spectroscopic analysis to elucidate the structure of organic compounds.

Course Learning Outcomes:

On successful completion of this course, the student should be able to understand:

1. Correlate theory and experimental findings to explore structural features of chemicals.
2. Apply the concept to establish structures of unknown compounds.

Course Content:**UNIT I: Microwave Spectroscopy****(08 Lectures)**

Interaction of electromagnetic radiation with molecules & various types of spectra and Born-Oppenheimer approximation. Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, and non-rigid rotor. Stark effect, nuclear and electron spin interaction, and the effect of external field. Applications.

UNIT II: Vibrational Spectroscopy**(10 Lectures)****A. Infrared Spectroscopy**

Linear harmonic oscillator, vibrational energies of diatomic molecules, zero-point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P, Q, R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities.

Applications of IR Spectroscopy:**(14 Lectures)**

IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on $>\text{C}=\text{O}$ stretching absorptions). Effect of H-bonding, conjugation, resonance and ring size on IR absorptions, Fingerprint region and its significance, application in functional group analysis.

B. Raman Spectroscopy

Classical & quantum theories of the Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Rule of the mutual exclusion principle. Resonance Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy (CARS).

UNIT III: UV Spectroscopy:**(10 Lectures)**

Types of electronic transitions, λ_{max} , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption, Application of Woodward - Fieser rules for calculation of λ_{max} for the following systems: α , β -unsaturated aldehydes, ketones, carboxylic acids and esters, Conjugated dienes: alicyclic, homoannular and heteroannular and extended conjugated systems (aldehydes, ketones and dienes). Distinction between cis and trans isomers.

UNIT IV: NMR Spectroscopy:**(10 Lectures)**

Basic principles of Proton Magnetic Resonance, factors influencing chemical shift, Spin-Spin coupling, coupling constant, Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

UNIT V: Mass Spectroscopy:**(8 Lectures)**

Basics of fragmentations in organic compounds. Discussion of molecular ion peak, base peak and metastable ions, McLafferty rearrangement. Nitrogen rule, Index of hydrogen deficiency. Application of fragmentation in the characterization of organic compounds. Problems in the structure elucidation of organic compounds based on spectral data. Applications of IR, UV, NMR and Mass spectra for the identification of simple organic molecules.

Reference Books:

1. Wiilam Kemp, Organic Spectroscopy, 3rd Edition ELBS, 2022
2. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*, UniversityScience Books, 1998
3. Rohatgi-Mukherjee K. K. *Fundamentals of Photochemistry*, New Age (revised secondedition).
4. Banwell C.N. & Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).
5. R.M. Silverstein, G.C. Bassler & T.C. Morrill: *Spectroscopic Identification of OrganicCompounds*, John Wiley & Sons.
6. John R. Dyer, *Applications of absorption spectroscopy of organic compounds*, Prentice Hall India (2012).

III. CORE COURSE
RESEARCH METHODOLOGY

[CCCHE103]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner can be able to understand:

1. To introduce students to the basics of research and scientific inquiry
2. To enable students to identify and define research problems
3. To familiarize students with various research methods, tools, and ethical practices
4. To develop basic skills in data collection, analysis, and reporting

Course Learning Outcomes:

Students would be able to understand:

1. Characteristics of good research viz; a comprehensive study of research reviews, gaps, objective, methodology, results, discussion and conclusion with future scope.
2. How to keep ethical considerations and stay away from plagiarism.

Course Content:**UNIT I: Introduction to Research**

(12 Lectures)

Definition and objectives of research, Types of research: basic, applied, qualitative, quantitative

Steps in the research process, Research questions and hypothesis formulation, Characteristics of good research

UNIT II: Research Design and Sampling

(12 Lectures)

Research design: exploratory, descriptive, experimental, Variables and control groups, Sampling methods: probability and non-probability, Sample size determination, Limitations and delimitations

UNIT III: Data Collection Methods

(12 Lectures)

Primary and secondary data, Techniques: questionnaires, interviews, observation, case studies

Survey tools and fieldwork, online and offline data collection, Validity and reliability of data

UNIT IV: Data Analysis and Interpretation

(16 Lectures)

Basics of data organization, Introduction to descriptive statistics: mean, median, mode, standard deviation

Graphical representation: tables, charts, graphs, Introduction to inferential statistics

Use of software tools (e.g., MS Excel, SPSS/R/PAST – demo-based)

UNIT V: Report Writing and Research Ethics

(08 Lectures)

Structure of a research report/thesis, Referencing and citation styles (APA/MLA)

Plagiarism and how to avoid it, Intellectual property rights and copyright

Ethical issues in research (including human and animal ethics)

Practical / Project Work

Framing a research question and writing a short proposal

Designing a sample questionnaire or data collection tool

Collecting mock data and presenting it using graphs or basic stats

Referencing using software like Zotero, Mendeley

Writing a mini-report based on collected data

Reference Books:

1. Kothari, C. R. – Research Methodology: Methods and Techniques.
2. Online resources: SWAYAM, NPTEL, and Google Scholar.
3. Kothari, C.R. and Garg, Gaurav, Research methodology: Methods and techniques, New Age International.
4. Breakwell, Glynis M. Hammond, S. Fifeschaw, C., Smith, J.A. Research Methods in Psychology, Sage Publications.
5. Kerlinger, Fred N., Foundation of Behavioral Research, Holt, Rinehart and Winston Publishing.
6. Ahuja, Ram. Research Methods, Rawat Publications.

IV. CORE COURSE
PHOTOCHEMISTRY

[CCCHE104]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The interaction between electromagnetic radiation and matter. Properties of Excited States.
2. Redox Reactions by Excited Metal Complexes. The role of spin-orbit coupling in complexes.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The photochemical stages – primary and secondary processes. The charge-transfer spectra, charge transfer excitations.
2. The Metal complex sensitizer and its relevance.

Course Content:**UNIT I: Introduction:**

(2 Lectures)

Some elementary aspects of photochemistry, electronic transitions, Fate of the excited molecules, Difference between photochemical and thermal reactions.

UNIT II: Photophysical and photochemical processes

(10 Lectures)

Laws of photochemistry, quantum yield. Jablonski diagrams: Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. kinetics of photochemical reactions ($H_2 + Br_2 \rightarrow 2HBr$, $H_2 + Cl_2 \rightarrow 2HCl$, $2HI \rightarrow H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and its applications).

UNIT III: Photochemical Inorganic Reactions

(10 Lectures)

Interaction of electromagnetic radiation with matter, types of excitations, transfer of excitation energy, Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck-Condon principle, photochemical stages – primary and secondary processes.

UNIT IV: Photochemical Organic reactions:

(6 Lectures)

Photolysis of propanone (acetone), cyclopentanone, Norrish type I and Norrish type II reactions. Photoreductive dimerization of diphenyl methanone (benzophenone), Photoisomerization of Cis- and trans-1,2-diphenylethene (Stilbene), Photosensitization, Photocycloaddition. Paterro – Biichi reaction, Photoinduced rearrangement reactions.

UNIT V: Excited States of Metal Complexes

(10 Lectures)

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

UNIT VI: Ligand Field Photochemistry

(10 Lectures)

Photosubstitution, photooxidation and photoreduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero zero spectroscopic energy and development of the equations for redox potentials of the excited states.

UNIT VII: Redox Reactions by Excited Metal Complexes

(12 Lectures)

Energy transfer under conditions of weak interaction and strong interaction-exciplex formation; conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2'-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidising character of Ruthenium (2+), (bipyridal complex, comparison with $Fe(bipy)_3$); role of spin-orbit coupling-life time of these complexes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low-energy reactants into high-energy products, and chemical energy into light.

Books Suggested:

1. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.
2. Inorganic Photochemistry, J. Chem. Educ., vol. 60, no. 10, 1983.
3. Progress in Inorganic Chemistry, vol. 30, ed. S.J. Lippard, Wiley.
4. Coordination Chem. Revs., 1981, vol. 39, 121, 131; 1960, 15, 321; 1990, 97, 313.
5. Photochemistry of Coordination Compounds, V. Balzari and V. Carassiti, Academic Press.
6. Elements of Inorganic Photochemistry, G. J. Ferraudi, Wiley.
7. IGNOU, CHE – 06 (4) , Organic Reaction and Mechanism.
8. Organic Chemistry; Sixth edition; R.T. Morrison and R.N. Boyd; Prentice-Hall of India Pvt.Ltd.
9. Organic Chemistry; 4th edition; Pine, Hendrickson cram, Hammond; McGraw – Hill Kogakushas Limited.
10. Reaction Mechanism and Reagents in Organic Chemistry; 12th edition. Gurdeep R. Chatwal. Himalaya Publishing House.
11. Molecular Reaction and Photochemistry; Charles H. Depay and Orville L. Chapman; Prentice Hall of India Private Limited.
12. Organic Synthesis; Ireland; Prentice Hall of India Private Limited.

**V. CORE COURSE
PRACTICAL-1**

[CCCHE105]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 6 Hrs) = 100

Pass Marks: = 45

(Credits: Theory-04, 60 Hours)

Instruction to Question Setter forEnd Semester Examination (ESE Pr):*There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:*

Experiment/Lab work	= 70 marks
Practical record notebook	= 05 marks
Attendance	= 05 marks
Viva-voce	= 20 marks

I. Qualitative Analysis:

Semi micro analysis of an Inorganic Mixture containing four acid and four basic radicals having one interfering radical. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

Cations: NH_4^+ , Pb^{2+} , Bi^{3+} , Cu^{2+} , Cd^{2+} , Sn^{2+} , Fe^{3+} , Al^{3+} , Co^{2+} , Cr^{3+} , Ni^{2+} , Mn^{2+} , Zn^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} including heavy metal ions.

Anions: CO_3^{2-} , NO_2^- , CH_3COO^- , Cl^- , Br^- , NO_3^- , SO_4^{2-} , PO_4^{3-} , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$

(Spot tests should be carried out wherever feasible)

II. Quantitative Analysis**Estimation of the following:**

- (a) Magnesium by E.D.T.A. Methods (Volumetrically)
- (b) Zinc by potassium ferrocyanide (Volumetrically)
- (c) Nickel by Dimethylglyoxime (Gravimetrically)
- (d) Managnese in steel by sodium bismuthate method.

III. Preparation of Inorganic Complexes

- (i) $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- (ii) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$
- (iii) Prussian Blue, Turnbull's Blue
- (iv) $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$
- (v) $[\text{Ni}(\text{dmg})_2]$
- (vi) Reineckle's Salt $\text{NH}_4[\text{Cr}(\text{NCS})_4(\text{NH}_3)_2] \cdot \text{H}_2\text{O}$

Reference Books:

1. Anastas, P.T. & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington, DC (2002).
3. Ryan, M.A. Introduction to Green Chemistry, Tinniesand (Ed), American Chemical Society, Washington, DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing, ISBN 978-93-81141-55-7 (2013).
5. Cann, M.C. and Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).
6. Cann, M. C. and Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008).
7. Lancaster, M. Green Chemistry: An Introductory Text, RSC Publishing, Second Edition, 2010.
8. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B. Saunders, 1995.

SEMESTER II**I. CORE COURSE**

[CCCHE201]

QUANTUM CHEMISTRY & NUCLEAR CHEMISTRY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner can be able to understand:

1. Black body radiation
2. The concept of wave function and its importance.
3. The Schrodinger wave equation
4. Applications of the variation method and perturbation theory
5. The concept of Angular momentum
6. The theories governing bonding in chemical substances.
7. The instability of nuclei and nuclear disintegration
8. The difference between Nuclear Fission and Fusion.
9. The Nuclear Reactor Theory.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Elucidating the Black body radiation and the Photoelectric effect.
2. To apply the Schrodinger wave equation
3. About spin-orbit coupling and Zeeman splitting
4. Comparison of LCAO-MO and VB treatments of H₂
5. About nuclear radiations and nuclear reactions and reactor theory.

Course Content:**UNIT I: Quantum Chemistry****Introduction to Quantum Chemistry**

(10 Lectures)

Introduction to black-body radiation and distribution of energy, photoelectric effect, concept of quantization, wave-particle duality (de-Broglie's hypothesis), Planck's Quantum theory. The uncertainty principle, the wave function, wave function and its interpretation, conditions of normalization and Orthogonality, and its significance. Basic idea about operators, eigenfunctions and eigenvalues.

UNIT II: The Schrodinger wave equation

(10 Lectures)

Postulates of quantum mechanics, the Schrodinger wave equation. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in one-dimensional box, three-dimensional box, the harmonic oscillator, the rigid rotor and the hydrogen atom. Schrodinger equation in spherical polar coordinates and separation of R_(r), Θ_(θ) & Φ_(φ) (radial and angular parts), degeneracies, spherical harmonics of the hydrogen atoms.

UNIT III: Approximate Methods for multi-electron system

(6 Lectures)

The variation method, Perturbation theory (first order and non-degenerate) and the W.K.B. method. Applications of the variation method and perturbation theory to the Helium atom.

UNIT IV: Angular momentum

(8 Lectures)

Ordinary angular momentum, generalized angular momentum (quantum mechanical approach), communication relation, eigenfunctions for angular momentum, eigenvalues of angular momentum. Operators: Ladder operators, raising and lowering operators, addition of angular momenta, spin, antisymmetric and Pauli exclusion principle.

UNIT V: Electronic Structure of Atoms

(8 Lectures)

Electronic configuration, Microstate, Term symbols, Russell- Saunders coupling schemes, Slater-Condon parameters, term separation energies for the dⁿ configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self-consistent field, the virial theorem.

UNIT VI: Nuclear Chemistry

(18 Lectures)

Systematic of alpha, beta and gamma decays

Alpha decay, energy curve, spectra of alpha particles, Giger-Nuttal law, theory of alpha decay, penetration of potential barrier, beta decay, range of energy relationship, beta spectrum, sergeants curve, Fermi theory of beta decay, matrix elements,

allowed and forbidden transitions, curie plots, gamma decay, nuclear energy levels, selection rule, isomeric transitions, Internal conversion, Auger effect.

Nuclear Structure and Stability

Nuclear Fission & Fusion, Binding energy, empirical mass equation, The nuclear models, the liquid drop model, the shell model, the Fermi gas model & collective nuclear model, nuclear spin, parity & magnetic moments of odd mass numbers nuclei. Symmetric and asymmetric fission, decay chains. Heavy water manufacturing.

Reference Books:

1. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
2. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
3. Peter, A. & Paula, J. de. *Physical Chemistry 9th Ed.*, Oxford University Press (2011).
4. Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
6. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011).
7. Laideler K. J. and Meiser J. M. *Physical Chemistry*, Third Edition (International) 1999
8. Levine I. N., *Physical Chemistry*, Fourth Edition, McGraw-Hill (International), 1995.
9. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*, University Science Books, 1998.
10. Banwell C.N. & Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).
11. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience
12. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice-Hall,
13. Overman R. T., Basic Concepts of Nuclear Chemistry, Chapman & Hall.
14. A. N. Nesmeyanov, Radiochemistry, MIR Publication, Moscow.
15. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry, Wiley
16. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, Second Edition.

II. CORE COURSE
MECHANISM IN ORGANIC CHEMISTRY

[CCCHE202]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
4. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, and identifying chiral centers.
5. Reactivity, stability of organic molecules, structure, and stereochemistry.
6. Electrophiles, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
7. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Understand the Mechanistic path of Organic reactions.
2. Decide the formation of reaction products other than the expected one.
3. Compare the stability of various intermediates formed in a chemical reaction.
4. Learn about the methods of Analysis of common useful substances.

Course Content:**UNIT I: Mechanism in Organic Chemistry**

(10 Lectures)

Structure and Reactivity, Types of mechanisms, types of reactions. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity, resonance and field effects, steric effect.

UNIT II: Aliphatic Nucleophilic Substitution

(12 Lectures)

The SN_2 , SN_1 , mixed SN_1 and SN_2 and SET mechanisms. Structural and electronic effects on SN_1 and SN_2 reactivity.

Solvent effects. Kinetic isotope effects. Intramolecular assistance: Electron transfer nature of SN_2 reaction.

The neighbouring group mechanism, neighbouring group participation by R and π -bonds, anchimeric assistance.

Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The SNi mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and ambident nucleophile.

UNIT III: Aliphatic Electrophilic Substitution

(05 Lectures)

Electrophilic reactivity, general mechanism. Bimolecular mechanisms- SE_2 and SE_i . The SE_1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity. Kinetics of SE_2 -Ar reaction. Structural effects on rates and selectivity.

UNIT IV: Addition to Carbon-Carbon Multiple Bonds

(5 Lectures)

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

UNIT V: Addition to Carbon-Hetero Multiple Bonds

(05 Lectures)

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, Organozinc and Organolithium reagents to carbonyl and unsaturated carbonyl compounds. Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

UNIT VI: Aromatic Electrophilic & Nucleophilic Substitution

(08 Lectures)

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, and orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction.

The SN_{Ar} , SN_1 , benzyne and SRN_1 mechanisms. Reactivity - effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.

UNIT VIII: Free Radical Reactions

(10 Lectures)

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate and neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity.

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

UNIT IX: Organic Reagents**1. Oxidizing Agents****(10 Lectures)**

OsO₄, KMnO₄, SeO₂, DDQ, PCC, PDC, TEMPO, NaOCl, MnO₂, Jones reagent, Collins reagent.

2. Reducing Agents**(08 Lectures)**

NaBH₄, LiAlH₄, DIBAL-H, BH₃, N₂H₂, BINAL, Wilkinson catalyst, Lindlar catalyst, Rosenmund catalyst.

Reference Books:

1. Reactions and Reagent, O.P. Agrawal.
2. UGC Advanced Organic Chemistry, Jagdamba Singh and LDS Yadav, Pragati Prakashan
3. Modern Methods of Organic Synthesis, W. Carruthers, Iain Coldham.
4. Organic Name Reactions: A unified approach, Goutam Brahmachari.
5. A Guidebook to Mechanism in Organic Chemistry, Peter Sykes.
6. Name Reactions: A Collection of Detailed Reaction Mechanisms, Jie Jack Li.
7. Strategic Applications of Named Reactions in Organic Synthesis, Laszlo Kurti, Barbara Czakó.
8. Organic Reaction Mechanisms, Raj K. Bansal.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh.
10. Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy, Michael G. Ellerd, Frank G. Favaloro, Jr.
1. Jerry March, *Advanced Organic Chemistry-Reactions, Mechanism and Structure*, John Wiley.
2. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).
3. Peter Sykes, *A Guide Book to Mechanism in Organic Chemistry*, Longman.
4. C. K. Ingold, *Structure and Mechanism in Organic Chemistry*, Cornell University Press.
5. R. T. Morrison and R. N. Boyd, *Organic Chemistry*, Prentice-Hall.
6. H. O. House, *Modern Organic Reactions*, Benjamin.
7. R. O. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, Blackie Academic & Professional.
8. S. M. Mukherji, *Pericyclic Reactions*, Macmillan, India.
9. S. M. Mukherji and S. P. Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan.
10. D. Nasipuri, *Stereochemistry of Organic Compounds*, New Age International.
11. P.S. Kalsi, *Stereochemistry of Organic Compounds*, New Age International.

III. CORE COURSE
GROUP THEORY & TRANSITION ELEMENTS

[CCCHE203]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The application of Group Theory in Spectroscopy.
2. The concept and relevance of symmetry elements.
3. The application aspects of various spectroscopic techniques.
4. Electronic Spectral Studies for d^1 - d^9 systems.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Understand the Mechanism of energy absorption in compounds.
2. Representation for the C_n , C_{nv} , C_{nh} , D_{nh} etc. groups.
3. Differentiate between Vibrational and Electronic spectroscopy.
4. Electronic spectra of transition metal complexes
5. Redox reactions, electron transfer reactions in complexes

Contents:**UNIT I: Symmetry & Group Theory**

(20 Lectures)

Symmetry elements and symmetry operations, definitions of group, subgroup, relation between orders of a finite group and its subgroups. 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 in spectroscopy.

UNIT II: Chemistry of d- and f-block elements

(10 Lectures)

Crystal field theory and splitting in O_h , T_d , D_{4h} and C_{4v} systems. Magnetic properties of transition metal complexes and lanthanides, metal-metal bonds, cluster compounds of d-block elements, poly-oxo metallates of Ru, Os, Mo. Structure and bonding in complexes containing π -acceptor ligands.

UNIT III: Electronic spectra of transition metal complexes

(15 Lectures)

Spectroscopic ground states, Term symbol, Selection rule, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1 - d^9 states), calculations of dq and β parameters, Racah parameters, oxidation states and electronic absorption spectra of complex ions. Spectrochemical series and effects of covalency. Nephelauxetic series charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

UNIT IV: Mechanism in Inorganic Reactions

(15 Lectures)

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidence in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Redox reactions, electron transfer reactions, mechanism of one-electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner-sphere type reactions

Books Suggested:

1. Jaffe, H.H. & Orchin, M. Symmetry in Chemistry Dover Publications (2002).
2. Cotton, F.A. Chemical Applications of Group Theory Wiley Interscience: N.Y(1990).
3. Hattfield, W. E. & Parker, W. E. Symmetry in Chemical Bonding & Structure C. E. Merrill Publishing Co. USA (1974).
4. Bishop, D.M. Group Theory and Chemistry, Clarendon Press: Oxford, U.K. (1973).
5. Shriver, D.F., Atkins, P.W. & Langford, C.H. Inorganic Chemistry, 2nd Ed., Oxford Univ. Press (1998).
6. Purcell, K.F. & Kotz, J.C. Inorganic Chemistry, W.B. Saunders and Co.: N.Y.(1985).
7. Wulfsberg, G. Inorganic Chemistry Univ. Science books: Viva Books: New Delhi (2000)
8. Mabbs, F.E. & Machin, D.J. Magnetism and Transition Metal Complexes Chapman and Hall: U.K. (1973).
9. Drago, R.S. Physical Methods in Chemistry W.B. Saunders Co.: U.K. (1982).

IV. CORE COURSE
ENVIRONMENTAL CHEMISTRY

[CCCHE204]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

5. The importance of Environment and its connect between various forms of life.
6. The role of abiotic components in sustaining life.
7. The components of Environments and about its protection.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. About Biochemical cycles of C, N, P, S and O.
2. The interconnect and relationship among Hydrosphere, Soil, Atmosphere.
3. The major sources of pollution.
4. About historical Environmental Toxicological disasters of the past.

Contents:**UNIT I: Environment**

(10 Lectures)

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

UNIT II: Hydrosphere

(15 Lectures)

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

UNIT III: Soils

(05 Lectures)

Composition, micro and macro nutrients, Pollution- fertilizers, pesticides, plastics and metals. Waste treatment.

UNIT IV: Atmosphere

(15 Lectures)

Chemical composition of atmosphere - particles, ions and radicals and their formation. Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons. Green-house effect, acid rain, air pollution controls and their chemistry. Analytical methods for measuring air pollutants. Continuous monitoring instruments.

UNIT V: Industrial Pollution

(8 Lectures)

Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers, drugs etc. Radionuclide analysis. Disposal of wastes and their management.

UNIT VI: Environmental Toxicology

(7 Lectures)

Chemical solutions to environmental problems, biodegradability, principles of decomposition, better industrial processes. Bhopal gas tragedy, Chernobyl, Three-mile island, Sewozo and Minamata disasters.

Books Suggested:

1. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
3. Environmental Chemistry, A. K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
5. Standard Method of Chemical Analysis, F.J. Weleher Vol. III. Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creachman, Gordon and Breach Science Publication.
8. Environmental Chemistry, C. Baird, W. H. Freeman.
9. Raziuddin, M., Mishra P.K. 2014, *A Handbook of Environmental Studies*, Akanaksha Publications, Ranchi.
10. Mukherjee, B. 2011: *Fundamentals of Environmental Biology*. Silverline Publications, Allahabad.
11. Carson, R. 2002. *Silent Spring*. Houghton Mifflin Harcourt.
12. Gadgil, M., & Guha, R. 1993. *This Fissured Land: An Ecological History of India*. Univ. of California Press.

**V. CORE COURSE
PRACTICAL-2**

[CPCHE205]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 6 Hrs) = 100

Pass Marks: = 45

(Credits: Theory-04, 60 Hours)

Course Content:

1. **Viscosity and Surface Tension**
 - (a) Determination of percentage composition of a mixture of two liquids by Ostwald tube.
 - (b) To determine the parachor of – CH₂, C and H
 - (c) Study of the effect of conc. on the surface tension of acetic acid and Sodium chloride solutions.
2. **Thermochemistry**
 - (a) Determination of water equivalent of a calorimeter
 - (b) Determination of the Heat of Neutralization of :
 - (i) Strong acid and strong base (HCl and NaOH)
 - (ii) Weak acid and strong base (NaOH and CH₃COOH).
 - (c) Determination of Heat of solution of Potassium Nitrate
 - (d) Determination of basicity of succinic Acid by Thermochemical Method.
3. **Order of Reaction**
 - (a) Determination of the rate constant of hydrolysis of an ester with an acid (Methyl acetate and HCl).
 - (b) Determination of the rate constant of saponification of ethyl acetate by NaOH.
4. **Partition Co-efficient**
 - (a) Determination of partition coefficient of:
 - (i) Benzoic acid between water and Benzene
 - (ii) Iodine between water and carbon tetrachloride
 - (b) Determination of Composition of Cupric-ammine sulphate formed between CuSO₄ and NH₃
 - (c) Determination of equilibrium constant for the reaction KI+I₂=KI₃

SEMESTER III**I. CORE COURSE****INDIAN KNOWLEDGE SYSTEM & METALLURGY**

[CCCHE301]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to:

1. Understand the historical context of Chemistry in Ancient India and its philosophical foundations.
2. Explore the evolution of metallurgy from Stone Age to Metal Age including discoveries of tin, gold, silver, brass, bronze and iron.
3. Analyze the significance of Zawar mines as the beginning of the Industrial Revolution in India.
4. Study the development of iron and steel technology and its impact on society.
5. Learn about Ayurveda and Alchemy as foundational pillars of Indian chemical sciences.
6. Appreciate the contribution of Indian knowledge systems to global science and technology.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Demonstrate an in-depth understanding of the evolution of chemistry and metallurgy in ancient India.
2. Interpret the processes of ancient mining, smelting and metal production techniques.
3. Analyze archaeological and textual evidence related to ancient chemical knowledge systems.
4. Evaluate the scientific significance of Indian iron pillars, alloys and industrial techniques.
5. Correlate the philosophical foundations of Ayurveda and Alchemy with the development of chemistry as a discipline.
6. Develop critical thinking and research aptitude in historical chemistry and its relevance to modern material science.

Course Content:**UNIT I: Introduction to Ancient Indian Chemistry:****(08 Lectures)**

Historical context of Ancient Indian Chemistry, philosophical foundations including Sāṅkhya—The atomic theory- Vaisesika Darshan- Theory of Maharshi Kanada Pātañjala, Vaiśeṣika and Nyāya chemical theories, early concepts of matter and five-element theory (Pañcikaraṇa), chemistry in Vedic and post-Vedic periods, contributions of Buddhists and Jains to chemical theory.

UNIT II: Metallurgy in Ancient India:**(12 Lectures)**

Transition from Stone Age to Metal Age. Evolution of Metallurgy from Stone, Copper, Bronze to Iron Age, discovery and use of tin, gold, silver, brass and bronze, case study of Aranmula Kannadi (metal mirror) as a metallurgical marvel, role of Zawar mines and zinc distillation as beginning of industrial revolution, archaeological and literary evidence for ancient smelting and alloy-making, trade, economy and cultural significance of metals.

UNIT III: Iron and Steel Traditions in Ancient India:**(08 Lectures)**

Introduction to Iron in Ancient India, Wootz steel, iron and steel production techniques, timeline and study of Indian Iron Pillars including Delhi, Dhar, Kodachadri and others, chemical analysis of rust-free iron pillars and their metallurgical significance, European observations on Indian iron and steel during 18th and 19th centuries.

UNIT IV: Ancient Indian Chemistry and Ayurveda:**(08 Lectures)**

Chemistry in Ayurveda with focus on Rasashastra, preparation of bhasma and rasa compounds, role of minerals, metals and herbs in therapeutic formulations, modern scientific validation of Ayurvedic processes and their relevance to pharmaceutical chemistry.

UNIT V: Introduction to Alchemy (Rasayana) in Ancient India:**(12 Lectures)**

Concept of Rasayana (alchemy) in Indian tradition, objectives of alchemy including transformation of base metals into noble metals and preparation of elixirs, religious, spiritual and medicinal significance of alchemical practices, relevance of ancient Indian alchemical practices in modern chemical research.

UNIT VI: Integrative Approaches in Chemistry:**(12 Lectures)**

Ancient Knowledge and Modern Science, Integration with Modern Chemistry: Comparative study of ancient metallurgical techniques with present-day extraction and refining methods, Ancient natural product chemistry (Ayurvedic formulations, bhasmas, herbal preparations) and their modern analytical validations, Traditional practices in environmental chemistry (water purification, sustainable agriculture) vis-à-vis green chemistry principles. Applications for the Future: Relevance of ancient sustainable chemical practices in modern times, Case studies of indigenous techniques inspiring current chemical research (e.g., nanomedicine parallels with bhasma preparations), Role of IKS in developing eco-friendly, low-cost, and innovative solutions for future chemical industries.

UNIT VII: Case Study: Field-Based Learning through Indian Knowledge System Heritage Sites in Jharkhand.

1. Deori Mandir (Ranchi)

- a. Highlight: Self-manifested Shiva Linga; tribal and Vedic integration.
- b. IKS Link: Ancient rituals, Tribal-Vedic synthesis, local Ayurvedic practices.

2. Navratangarh Fort (Gumla)

- a. Highlight: Architectural blend of tribal and Mughal techniques.
- b. IKS Link: Political science, defense architecture, resource management.

3. Palamu Forts (Betla National Park)

- a. Highlight: Ancient military architecture and water systems.
- b. IKS Link: Traditional water conservation, strategic design.

4. Shikharji Circuit (Jharkhand)

- a. Highlight: Jain tirtha with rich environmental tradition.
- b. IKS Link: Sacred ecology, spiritual environmentalism.

Essential Readings

1. Indian Science and Technology in the Eighteenth Century (2000) by Dharampal, Other India Press.
2. History of Hindu Chemistry Vol 1 (1903) and Vol 2 (1909) by P.C. Ray; The Bengal Chemical and Pharmaceutical Works, Ltd.
3. The Positive Sciences of the Ancient Hindus by Brajendranath Seal; Longman Greens and Co., Kolkata, 1915.
4. A concise history of science in India; Edited by D. M. Bose, S.N. Sen and B. V. Subbarayappa; Indian National Science Academy, New Delhi; 1971.
5. History of Science and Technology in Ancient India- The Beginnings; by Debiprasad Chattopadhyay; FIRMA KLM Pvt. Ltd. Kolkata; 1986 (Reprinted in 1996).
6. History of Technology in India; Edited by A.K. Bag; Indian National Science Academy, New Delhi; 1997.

Suggested Readings

1. S. Prakash, Founders of Science in Ancient India, The Research Institute of Ancient Studies, New Delhi (1965).
2. Prakash B, 2001, Ferrous Metallurgy in Ancient India, NML Jamshedpur 831 007, India, page no. 52-91.
3. Dr. Siddhinandan Mishr, Ayurvedeeda Rasashastra.

Case Study:

1. IGNCA – *Indian Cultural Heritage Studies*
2. Kapil Kapoor – *Text and Interpretation in Indian Traditions*
3. Michel Danino – *The Lost River & Indian Roots of Science*
4. Dharampal – *Indian Science & Technology in the 18th Century*
5. Subhash Kak – *The Astronomical Code of the Rgveda*
6. Ministry of Tribal Affairs – *Tribal Culture and Practices*
7. Jharkhand Tourism Board – *Heritage and Culture Booklets*
8. Prof. R. Balasubramaniam – *Studies on Iron and Metallurgy in Ancient India*
9. ASI (Eastern Circle) Reports – *Jharkhand Archaeological Survey*
10. IKS Division, AICTE – *Field Visit Guidelines and Learning Tools*

II. SKILL ENHANCEMENT COURSE
BIO-CHEMISTRY

[ECCHE302]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The role of metal ions in the biological system,
2. ATP as the energy currency of living cells.
3. Transport and Storage of Dioxygen in living organisms.
4. The function of metalloproteins in electron transport processes
5. Enzymes and Mechanism of Enzyme Action
6. Biotechnological Applications

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Forces involved in biopolymer interactions.
2. Photosystem I & II and its importance.
3. Heme proteins and oxygen uptake
4. Biological nitrogen fixation.
5. Mechanism of Enzyme Action.
6. Biological Cell and its constituents.
7. Thermodynamics of biopolymer Solutions.

Course Content:**GROUP-A (Bioinorganic Chemistry)****UNIT I: Metal Ions in Biological Systems**

(02 Lectures)

A brief introduction to bio-inorganic chemistry. Geochemical effect on distribution of metals. Essential and trace metals. Role of metals ions in biological processes, systems with special reference to Na^+ , K^+ and Mg^{2+} ions: Na/K pump, Role of Mg^{2+} ions in energy production and chlorophyll. Iron and its application in bio-systems, Haemoglobin, Myoglobin, Storage and transfer of iron. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

UNIT II: Bioenergetics and ATP Cycle

(05 Lectures)

DNA polymerisation, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem I and photosystem II in cleavage of water. Model systems.

UNIT III: Transport and Storage of Dioxygen

(06 Lectures)

Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper.

UNIT IV: Electron Transfer in Biology

(05 Lectures)

Structure and function of metalloproteins in electron transport processes - cytochromes and ion-sulphur proteins, synthetic models

UNIT V: Nitrogenase

(05 Lectures)

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

GROUP-B (Bioorganic Chemistry)**UNIT VI: Enzymes and Mechanism of Enzyme Action**

(10 Lectures)

Basic considerations. Proximity effects and molecular adaptation. Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible Inhibition.

Mechanism of Enzyme Action: Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

UNIT VII: Enzyme Catalysed Reactions

(05 Lectures)

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

UNIT VIII: Co-Enzyme Chemistry
(04 Lectures)

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

UNIT IX Biotechnological Applications of Enzymes
(04 Lectures)

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

GROUP-C (Biophysical Chemistry)
UNIT X: Biological Cell and its constituents
(02 Lectures)

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

UNIT XI: Biopolymer Interactions
(04 Lectures)

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

UNIT XII: Thermodynamics of biopolymer Solutions
(04 Lectures)

Thermodynamics of biopolymer Solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.

UNIT XIII: Cell Membrane and Transport of Ions
(04 Lectures)

Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamic treatment of membrane support, Nerve conduction.

Books Suggested:

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 Biochemistry vols I and II. ed. G.L. Eichhorn, Elsevier.
4. Progress in Inorganic Chemistry, Vols 18 and 3S ed. J.J. Lippard, Wiley.
5. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
6. Understanding Enzymes, Trevor Palmer, Prentice Hall.
7. Enzyme Chemistry: Impact and Applications, Ed. Collin J Suckling, Chapman and Hall.
8. Enzyme Mechanisms Ed, M. 1. Page and A. Williams, Royal Society of Chemistry.
9. Fundamentals of Enzymology, N.C. Price and L. Slovens, Oxford University Press.
10. Immobilized Enzymes: An Introduction and Applications In Biotechnology, Michael O. Trevan, John Wiley.
11. Enzymatic Reaction Mechanisms, C. Walsh, W. H. Freeman.
12. Enzyme Structure and Mechanism, A Fersht, W.H. Freeman.
13. Biochemistry: The Chemical Reactions of Living Cells, D. E. McUler, Academic Press.

III. CORE COURSE

[CCCHE303]

APPLICATIONS OF SPECTROSCOPY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The principle involved in Microwave spectroscopy.
2. The IR range and the applicable range for spectral instruments.
3. The difference between IR and Raman spectra.
4. The application aspects of various spectroscopic techniques.
5. The applications of Ultraviolet and Visible Spectroscopy for various types of conjugated systems.
6. McLafferty rearrangement

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Understand the Mechanism of energy absorption in compounds.
2. Differentiate between Vibrational and Electronic spectroscopy.
3. Fieser-Woodward rules for conjugated dienes and carbonyl compounds.
4. The characteristic vibrational frequencies of organic compounds.
5. The shielding mechanism, chemical shift values and correlation for protons bonded to carbon and other nuclei.
6. Ionisation techniques like El, Cl, FD and FAB.
7. Factors affecting fragmentation

Course Content:

GROUP-A Inorganic Chemistry

UNIT I: Electronic Spectroscopy

(07 Lectures)

Electronic Spectral Studies for d^1 - d^9 systems in octahedral, tetrahedral and square planer complexes,**UNIT II: Vibrational Spectroscopy**

(05 Lectures)

Symmetry and shapes of AB_2 , AB_3 , AB_4 , AB_5 and AB_6 , mode of bonding of ambidentate ligands, nitrosyl, ethylenediamine and diketonato complexes, application of resonance. Raman spectroscopy and its applications.**UNIT III: Electron Spin Resonance Spectroscopy**

(07 Lectures)

Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors (g-parallel, g-perpendicular, electron cloud distortion, application in plot), application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as PH_4^- , F_2^- and $[BH_3]^-$ (also deuterated compounds).**UNIT IV: Mössbauer Spectroscopy**

(05 Lectures)

Basic principles, spectral parameters and spectrum display. Application of the technique 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.

GROUP-B Organic Chemistry

UNIT V: Ultraviolet and Visible Spectroscopy

(05 Lectures)

Various electronic transitions (185-800 nm), Beer—Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.

UNIT VI: Infrared Spectroscopy

(08 Lectures)

Instrumentation and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrations frequencies, overtones, combination bands and Fermi resonance. FT IR. IR of gaseous, solids and polymeric materials.

UNIT VII: Nuclear Magnetic Resonance Spectroscopy

(10 Lectures)

Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, factors influencing coupling constant "j" Classification, spin decoupling; basic ideas about the instrument, NMR studies of nuclei other than proton- ^{13}C , ^{19}F and ^{31}P . FT NMR, advantages of FT NMR.**PMR Spectroscopy**

Implemented from Academic Session 2025-26 & Onwards

Introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, deshielding, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, solvent effects. Fourier transform technique.

Carbon-13 NMR Spectroscopy
(05 Lectures)

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two-dimensional NMR spectroscopy - COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

UNIT VIII: Mass Spectrometry
(10 Lectures)

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, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS).

Spectrophotometric (UV/VIS) Estimations of: Amino acids, Proteins, Carbohydrates, Cholesterol, Ascorbic acid, Aspirin, Caffeine

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho. Wiley Interscience.
3. NMR, NOR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Chemical Applications of Group Theory, F. A. Cotton.
6. Introduction to Molecular Spectroscopy, Q.M. Barrow, McCraw Hill.
7. Basic Principles of Spectroscopy. R. Chang, McGraw Hill.
8. Theory and Applications of UV Spectroscopy, H.H. Jatie and M. Orechin, IBH-Oxford.
9. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
10. Introduction to Magnetic Resonance, A. Carrington and A.D. MacLachlan, Harper & Row.
11. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
12. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
13. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
14. Progress in Inorganic Chemistry vol., 8, ed., F.A. Cotton, vol., 15, ed. S.J. Lippard, Wiley.
15. Transition Metal Chemistry, R.L. Carlin voi. S. Dekker
16. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
17. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.
18. Spectrometric identification of Organic Compounds, R. M. Silverstein, Q. C. gassier and T. C. Morrill, John Wiley
19. Introduction to NMR Spectroscopy. R. J. Abraham, J. Fisher and P. Loftus, Wiley.
20. Application of Spectroscopy of Organic Compounds, J. R. Dyer, Prentice Hall.
21. Spectroscopic Methods in Organic Chemistry, D. H. Williams, I. Fleming, Tala McGraw-Hill.

IV. CORE COURSE
ANALYTICAL CHEMISTRY

[CCCHE304]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner will be able to understand:

1. Different types of Redox reactions.
2. Electronic spectra of inorganic molecules.
3. The application of statistical methods in analytical techniques.
4. Different chromatographic techniques.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Select appropriate techniques of Analysis.
2. Report results in correct significant figures.
3. Select appropriate method of chromatographic separation techniques.

Course Content:**UNIT I: Introduction of Analytical Chemistry**

(04 Lectures)

Role of analytical chemistry. Classification of analytical methods-classical and instrumental. Types of instrumental analysis. Selecting an analytical method. Sample preparations - dissolution and decompositions. Gravimetric techniques. Selecting and handling of reagents. Concept of sampling.

UNIT II: Statistical methods in chemical analysis

(10 Lectures)

Importance of accuracy, precision and sources of error in analytical measurements. Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, Q-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).

UNIT III: Food Analysis

(08 Lectures)

Moisture, ash, crude protein, fat, crude fibre, carbohydrates, calcium, potassium, sodium and phosphate. Food adulteration-common adulterants in food, contamination of food stuffs. Microscopic examination of foods for adulterants. Pesticide analysis in food products. Extraction and purification of sample. HPLC. Gas chromatography for organophosphates. Thin-layer chromatography for identification of chlorinated pesticides in food products.

UNIT IV: Analysis of Water Pollution

(10 Lectures)

Origin of waste water, types, water pollutants and their effects. Sources of water pollution-domestic, industrial, agricultural soil and radioactive wastes as sources of pollution. Objectives of analysis-parameter for analysis-colour, turbidity, total solids, conductivity, acidity, alkalinity, hardness, chloride, sulphate, fluoride, silica, phosphates and different forms of nitrogen. Heavy metal pollution-public health significance of cadmium, chromium, copper, lead, zinc, manganese, mercury and arsenic. General survey of instrumental technique for the analysis of heavy metals in aqueous systems. Measurements of DO, BOD and COD. Pesticides as water pollutants and analysis. Water pollution laws and standards.

UNIT V: Analysis of Soil, Fuel, Body Fluids and Drugs

(10 Lectures)

- a. Analysis of soil: moisture, pH, total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts.
- b. Fuel analysis: solid, liquid and gas. Ultimate and proximate analysis-heating values grading of coal. Liquid fuels-flash point, aniline point, octane number and carbon residue. Gaseous fuels-producer gas and water gas-calorific value.
- c. Clinical chemistry: Composition of blood-collection and preservation of samples. Clinical analysis. Serum electrolytes, blood glucose, blood urea nitrogen, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphatases. Immunoassay: principles of radio immunoassay (RIA) and applications. The blood gas analysis trace elements in the body.
- d. Drug analysis: Narcotics and dangerous drugs. Classification of drugs. Screening by gas and thin-layer chromatography and spectrophotometric measurements.

UNIT VI: Separation techniques:

(12 Lectures)

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter

current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique. Paper, column and thin layer chromatography, Gas-liquid chromatography, HPLC. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

UNIT VII: Thermal analysis:**(6 Lectures)**

Theory, methodology, instruments and applications of thermogravimetric analysis (TGA/DTA), and differential scanning calorimetry (DSC).

Reference Books:

1. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
2. Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA. 16 (1977).
3. Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India.
4. Ditts, R.V. *Analytical Chemistry, Methods of separation*, van Nostrand, 1974.

**V. CORE COURSE
PRACTICAL-3**

[CCCHE305]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 6 Hrs) = 100

Pass Marks: = 45

(Credits: Theory-04, 60 Hours)

Practicals:

1. Practical Component

1. The principle of natural vinegar formation and the use of various initial components such as iron piece in the process.
2. The use of natural vinegar in ancient chemistry experiments and its comparison with synthetic vinegar of modern world.
3. Vinegar, in electrochemical cell as acidic electrolyte can be tested. A simple electrolytic cell can be assembled with vinegar solution.
4. pH indicators as in case of paan, where green colored betel leaf when mixed with white colored calcium carbonate and brown colored areca-nut gives a red color.

2. Extraction of Organic compounds from Natural sources: (Any two)

Isolation of caffeine from tea leaves. Isolation of nicotine dipicrate from tobacco. Isolation of cinchonine from cinchona bark. Isolation of piperine from black pepper. Isolation of lycopene from tomatoes. Isolation of β -carotene from carrots. Isolation of oleic acid from olive oil involving the preparation of complex with urea and separation of linoleic acid. Isolation of eugenol from cloves. Isolation of (+) limonine from citrus rinds

3. Experiments-I (Lab-work)

Group-A: Estimation of following in water

Group-B: Analysis of soil for the followings

4. Organic preparations:

1. Preparation of Aniline Yellow.
2. Preparation of Methyl Orange.
3. Preparation of urea-formaldehyde resin

5. Organic Qualitative Analysis

- (a) Identification of organic compounds containing one functional group using Chemical & Spectral Analysis
- (b) Separation, purification and identification of binary mixture (one liquid and one solid) involving TLC and Column Chromatography. Chemical tests and Functional group identification.

Reference Books:

1. F. Brians, J. H. Antony, P. W. G. Smith and R. T. Austin, Vogel's text book of practical organic chemistry, ELBS, 5th Edn. 1991.
2. R. K. Bansal, Laboratory manual of organic chemistry, 3rd Edn. Wiley Eastern Limited, 1994.
3. D. H. Williams and Ian Fleming, Spectroscopic methods in organic chemistry, TMH Edition, 1988.
4. A. Buzarbarua, A Text Book of Practical Plant Chemistry, S. Chand and Company Ltd., 2000.
5. S. Sadasivam and A. Manikam, Biochemical Methods, Wiley Eastern, 1992.
6. D. L. Pavia, G. M. Lampman and G. S. Kriz, Introduction to Spectroscopy, 3rd Edn. Harcourt College Publishers, 2007.

SEMESTER IV**I. ELECTIVE COURSE-1A
INORGANIC CHEMISTRY-1A**

[ECCHE401A]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100**Pass Marks: (MSE: 17 + ESE: 28) = 45****(Credits: Theory-04, 60 Hours)****Course Objectives:**

On completion of this course, the students will be able to understand:

1. The metalorganic reagents and their role in synthesis.
2. The chemistry of Compounds of Transition Metal-Carbon Multiple Bonds.
3. Transition Metal π -Complexes and their reactions.
4. Homogeneous Catalysis. Fluxional Organometallic Compounds.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. The reactions of organocopper reagents in organic chemistry.
2. The chemistry of Transition metal π -complexes with unsaturated organic molecules.
3. Homogeneous Catalysis
4. Fluxionality and dynamic equilibria in compounds

Course Content:**UNIT I: Metal Alkyls and Aryls of Transition Metals:****(06 Lectures)**

Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis. Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicenter bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

UNIT II: Compounds of Transition Metal-Carbon Multiple Bonds**(08 Lectures)**

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: Transition Metal π -Complexes**(10 Lectures)**

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

UNIT IV: Transition Metal Compounds with Bonds to Hydrogen**(10 Lectures)**

Transition Metal Compounds with Bonds to Hydrogen. Synthesis, Nature of Bond and important reactions.

UNIT V: Homogeneous Catalysis**(10 Lectures)**

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

UNIT VI: Fluxional Organometallic Compounds**(10 Lectures)**

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

UNIT VII: Catalysis by Organometallic Compounds**(06 Lectures)**

Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinson's Catalyst), Hydroformylation (Co salts), Wacker Process, Synthetic gasoline (Fischer Tropsch reaction), Synthesis gas by metal carbonyl complexes

Books Suggested:

1. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdsus, J.R. Norton and R.G. Pinke, 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.

OR ELECTIVE COURSE-1B
ORGANIC CHEMISTRY-1B

[ECCHE401B]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. Curve Crossing Model to Chemical Reactions
2. Structural Effects on Reactivity
3. Supramolecular Chemistry and its scope.
4. The importance of Alkaloid chemistry.
5. The importance of Steroids as a part of living system.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Valence bond (VB) configuration mixing diagrams.
2. Relationship between VB configuration mixing and resonance theory.
3. The importance of Barrier concept in the reaction.
4. Primary and secondary kinetic isotope effects.
5. Principal forces in Supramolecular Chemistry.
6. The importance of Terpenoids, Carotenoids, Alkaloids and Steroids.

Course Content:**UNIT I: Curve Crossing Model to Chemical Reactions****(14 Lectures)**

Valence bond (VB) configuration mixing diagrams. Relationship between VB configuration mixing and resonance theory. Reaction profiles. Rules for constructing Valance Bond Correlation Diagram. Reactivity pattern based on Valance Bond State Correlation Diagram (VBSCD model). Curve crossing model-nature of activation barrier in chemical reactions.

V.B. Correlation diagram for

One Bond Reactions: V.B. Configuration of Ionic Bond. Heterolysis of Polar Covalent bond in solutions.

Two Bond Process: Covalent Bond: Radical Exchange Reactions, Nucleophilic Exchange Reactions, Nucleophilicity and S_N2 reactivity based on curve-crossing model. Electrophilic Exchange Reactions. Curve-crossing approach to electrophilic reactivity; Ionic Bond.

UNIT II: Principles of Reactivity**(05 Lectures)**

Mechanistic significance of entropy, enthalpy and Gibb's free energy. Arrhenius equation. Transition state theory. Uses of activation parameters, Hammond's postulate. Bell-Evans -Polanyi principle. Potential energy surface model. Marcus theory of electron transfer. Reactivity and selectivity principles.

UNIT III: Kinetic Isotope Effect**(04 Lectures)**

Theory of isotope effects. Primary and secondary kinetic isotope effects. Heavy atom isotope effects, Tunneling effect. Solvent effects.

UNIT IV: Structural Effects on Reactivity**(05 Lectures)**

Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Interpretation of σ -values. Reaction constant ρ . Deviations from Hammett equation. Dual-parameter correlations, inductive substituent constant. The Taft model, σ_L -and σ_R scales.

UNIT V: Supramolecular Chemistry**(06 Lectures)**

Properties of covalent bonds - bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarizability, bond dissociation enthalpy, entropy.

Intermolecular forces, hydrophobic effects. Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects. Hydrogen bond.

Principles of molecular association and organization as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model systems like micelles and vesicles. Molecular receptors and design principles. Cryptands, cyclophanes, calixeranes, cyclodextrines. Supramolecular reactivity and catalysis. Molecular channels and transport processes. Molecular devices and nanotechnology.

UNIT VI: Terpenoids and Carotenoids**(08 Lectures)**

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, α -Terpeneol, Zingiberene and β -Carotene.

UNIT VII: Alkaloids**(08 Lectures)**

Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Nicotine, Quinine, Morphine and Narcotine.

UNIT VIII: Steroids**(10 Lectures)**

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone.

Books Suggested:

1. Molecular Mechanics, U. Burkert and N. L. Allinger, ACS Monograph 177, 1982.
2. Organic Chemists' Book of Orbitals. L. Salem and W. L. Jorgensen, Academic Press.
3. Mechanism and Theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.
4. Introduction to Theoretical Organic Chemistry and Molecular Modeling, W. B. Smith, VCH, Weinheim.
5. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman.
6. The Physical Basis of Organic Chemistry, H. Maskill, Oxford University Press.
7. Natural Products: Chemistry and Biological Significance, J. Mann, R. S. Davison, J. B. Hobbs, D. V. Banthrope and J. B. Harborne, Logman, Essex.

OR ELECTIVE COURSE-1C
PHYSICAL CHEMISTRY-1C

[ECCHE401C]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The Application of Statistics in Thermodynamics.
2. The free electron theory and Metallic conduction.
3. The Kohlrausch's law and its applications.
4. The factors affecting corrosion.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. The Applications of partition function.
2. The differences between metallic conductors, insulator and semiconductors.
3. The Inter-conversion of translational and vibrational energies.
4. The nature of slow reactions like Corrosion and Fast Reactions like Flash Photolysis.

Course Content:**UNIT I: Statistical thermodynamics:**

(12 Lectures)

Theorem of probability, Fundamentals of statistical methods, Most probable distribution and Maxwell-Boltzmann distribution law of energy; Entropy and probability, partition functions and their relation to thermodynamic quantities – calculations for model systems. Third Law of Thermodynamics and Partition Function. Applications of partition function of monotonic gases; Partition function for diatomic molecules.

UNIT II: Metallic bonds

(10 Lectures)

Free electron theory, band theory, Fermi level, Brillouin zone, wave function for electrons in solids, metallic conductors, insulator, semiconductors (intrinsic & extrinsic), properties of junctions.

UNIT III: Potential Energy Surfaces

(15 Lectures)

Mechanism of activation, potential energy surface for three atom reaction, Potential energy curve for successive reactions, Properties of potential energy surfaces, Inter-conversion of translational and vibrational energies, Combination of atoms, Orthopara conversion, Activated state of three atom and four atom reactions, Potential energy profile, reaction co-ordinate, Transmission co-efficient, non-adiabatic reaction.

UNIT IV: Electrochemistry & Corrosion

(15 Lectures)

Electrochemical cells; electrolytic conductance, Kohlrausch's law and its applications; Debye-Huckel theory; Debye-Huckel-Onsager equation. Thermodynamics of electrified interfaces. Electrical double layer, Discharge potential, Overpotential or overvoltage. Electrocatalysis: Introduction, Relative power of electrocatalysts, Mechanism of electrocatalysis, Bioelectrocatalysis.

Corrosion: Introduction, Factors affecting corrosion, Corrosion inhibitors, Passivity, Types of corrosion, Protection from corrosion control or corrosion control.

UNIT V: Study of Fast Reactions

(08 Lectures)

Photo physical Chemistry-Flash Photolysis, Relaxation technique, Nuclear Magnetic Resonance Method, Molecular Beam and Shock-tube Kinetics, Flow method.

Reference Books:

1. Rastogi, R. P., Introduction to Non-equilibrium Physical Chemistry, Elsevier B.V. (2008)
2. Kalidas, C. & Sangaranarayanan, M.V. Non-Equilibrium Thermodynamics: Principles & Applications, Macmillan India Ltd. (2002).
3. Katchalsky, A. & Curren, P. F. Non-Equilibrium Thermodynamics in Biophysics Harvard University Press: Cambridge (1965).
4. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
5. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
6. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
7. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol. 3, 6th Edition, McGraw-Hill Education.
8. Laidler K.J. (2003), Chemical Kinetics, 3rd Edition, Pearson Education India.

**II. ELECTIVE COURSE-2A
INORGANIC CHEMISTRY-2A**

[ECCHE402A]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The Metal Storage Transport and Biominerilization.
2. The Metal-Nucleic Acid Interactions.
3. The Supramolecular Chemistry and its applications.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. The role of Ferritin, transferrin, and siderophores in biological processes.
2. The metals used for diagnosis and chemotherapy.
3. The role of metal ions in life, effect of Metal deficiency and disease and toxic effects of excess metals.
4. Supramolecular reactivity and catalysis.
5. About Supramolecular devices and self-assembly in supramolecular chemistry.

Course Content:**UNIT I: Metal Storage Transport and Biominerilization (05 Lectures)**

Ferritin, transferrin, and siderophores – Structure and role in Iron storage.

UNIT II: Calcium in Biology (10 Lectures)

Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extracellular binding proteins

UNIT III: Metalloenzymes (15 Lectures)

Zinc enzymes - carboxypeptidase and carbonic anhydrase. Iron enzymes - catalase, peroxidase and cytochrome P-450. Copper enzymes - superoxide dismutase. Molybdenum oxatransferase enzymes - xanthine oxidase. Coenzyme vitamin BII

UNIT IV: Metal-Nucleic Acid Interactions (07 Lectures)

Metal ions and metal complex interactions. Metal complexes - nucleic acids and their applications

UNIT V: Metals in Medicine (05 Lectures)

Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs

UNIT VI: Supramolecular Chemistry (18 Lectures)

Concepts and language.

- Molecular recognition: Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of coreceptor molecules and multiple recognition.
- Supramolecular reactivity and catalysis.
- Transport processes and carrier design.
- Supramolecular devices. Supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Some example of self-assembly in supramolecular chemistry

Books Suggested:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, 1. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Inorganic Biochemistry vols I and II. ed. O.L Eichhom, Elsevier.
4. Progress in inorganic Chemistry, Vols 18 and 38 ed. J.J. Lippard, Wiley.
5. Supramolecular Chemistry, J.M. Lehn, VCH.

OR ELECTIVE COURSE-2B
ORGANIC CHEMISTRY-2B

[ECCHE402B]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The principles, mechanisms, and applications of pericyclic reactions in organic chemistry.
2. The Chemistry of Heterocycles.
3. The isolation, need, structure of Vitamins.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The Chemistry of Pericyclic reactions, Heterocyclics and Vitamins.

Course Content:**UNIT I: Pericyclic Reactions**

(15 Lectures)

Radical stability, polar influences, solvent and steric effects. A curve crossing approach to radical addition, factors effecting barrier heights in additions, regioselectivity in radical reactions, Reactivity, specificity and periselectivity in pericyclic reactions.

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach.

Electrocyclic reactions-conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl systems. Cycloadditions-antarafacial and suprafacial additions, $4n$ and $4n+2$ systems. $2+2$ addition of ketenes, 1,3 dipolar cycloadditions and cheletropic reactions.

Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, sigmatropic involving carbon moieties, 3,3- and 5,5-sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction, Click reaction.

UNIT II: Heterocycles: Nomenclature & Classification

(10 Lectures)

Replacement and systematic nomenclature (Hantzsch MCH-Widman system) for monocyclic fused and bridged heterocycles. Criteria of aromaticity including ring current and chemical shifts in ^1H NMR spectra.

Heterocyclic Synthesis: Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions.

UNIT III: Small ring Heterocycles

(09 Lectures)

Three, Four & Five membered heterocycles including medicinal applications of benzopyrroles, benzofurans and benzothiophenes

UNIT IV: Heterocycles with one Heteroatom

(08 Lectures)

Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

UNIT V: Six-Membered Heterocycles with Two or More Heteroatoms

(06 Lectures)

Synthesis and reactions of diazines, triazines, tetrazines and thiazines

UNIT VI: Vitamins

(12 Lectures)

Determination and Synthesis of Vit. A, B₁, B₂, B₆, Vit. C and Vit. D.

Books Suggested:

1. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
2. Molecular Mechanics, U. Burkert and N.L. Allinger, ACS Monograph 177, 1982.
3. Introduction to Theoretical Organic Chemistry and Molecular modelling, W.B. Smith, VCH, Weinheim.
4. Heterocyclic Chemistry Vol. 1-3, R. R. Supta, M. Kumar and V Gupta, Springer Verlag.
5. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
6. Heterocyclic Chemistry, J. A. Joule, K. Mills and G.F. Smith, Chapman and Hall.
7. Contemporary Heterocyclic Chemistry, Q. R. Newkome and W. W. Paudler, Wiley-Interscience.
8. An introduction to the Heterocyclic Compounds. Linds, R. M. Acheson, John Wiley.
9. Organic Chemistry, Vol 2, I. L. Finar, ELBS.
10. Stereoselective Synthesis; A Practical Approach, M. Nogradi. VCH.
11. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M I Choudhary, Harwood Academic Publishers.

OR ELECTIVE COURSE-2C
PHYSICAL CHEMISTRY-2C

[ECCHE402C]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The difference between Conductivity and superconductivity.
2. The Chemistry of surfaces and colloids. The Polymer chemistry and its uses.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The conventional organic and high temp. superconductors.
2. Kinetics of surface processes. Surface active agents or surfactants.
3. Factors related with the Kinetics of Condensed Phase Reactions

Course Content:**UNIT I: Superconductivity****(10 Lectures)**

Superconductivity, Meissner effect, microscopic theory of superconductivity, conventional organic and high temp, superconductors, fullerenes, applications of superconductors.

Transformation in crystals - thermodynamics of transformation, order-disorder transitions, martensitic transition, polymorphic transformation

UNIT II: Specific heat of solids**(08 Lectures)**

Specific heat of solids, classical theory, quantum theory of specific heats-Einstein and Debye theories, characteristic temp and its calculation, T-law. Solid state reactions, laws governing nucleation, homogeneous and heterogeneous nucleation, and thermodynamic barrier.

UNIT III: Surface chemistry**(10 Lectures)**

Absorption vs Adsorption, Surface chemistry, surface films, Types of adsorptions. Adsorption isotherms, BET isotherm for multilayers & its derivation, Gibbs adsorption equation. Kinetics of surface processes, unimolecular and bimolecular surface reactions, electrocapillarity, electrokinetic effects, statistical mechanics of adsorption.

UNIT IV: Colloidal state and Micelles**(08 Lectures)**

Colloids: Size of colloidal particles, Classification of Colloidal system, Preparation & purification of sols. General properties of colloidal solutions, Coagulation, Electrical properties, and stability of colloids. Surface active agents or surfactants, Micelles. Emulsions and colloids around us.

UNIT V: Polymers:**(12 Lectures)**

Polymer solution, thermodynamics of polymer solutions, molar mass and molar mass distribution, methods of measuring molar masses, micelle formation and hydrophobic interaction.

Electrically conducting polymers: Electrically conducting polymers electrochemical polymerization, band structure of polymers, mechanism of conduction in polymers, doping of polymers, application of conduction polymers.**Polymer liquid crystal:** Polymer liquid crystal nematic, cholesteric and smectic phases, liquid crystalline order of the main chain and of the side groups in polymers, synthesis and properties of polymer liquid crystals, liquid crystalline order in biological materials.**UNIT VI: Kinetics of Condensed Phase Reactions****(12 Lectures)**

Rate determining steps in diffusion-controlled reactions and activation-controlled reactions, Stokes-Einstein equation and dependence of rate constant on co-efficient of viscosity of medium, Kinetics of ionic reactions in solution-electrostatic contribution to free energy in single and double spherical models of activated complex, entropy of activation for ion-ion reactions; Kinetics of dipole-dipole reaction, ion-dipole reaction, dependence of rate constant on ionic strength and dielectric constant of medium, Bronsted-Bjerrum equation.

Books Suggested:

1. Crystallography - Philips
2. Solid State Chemistry-Garner (Butterworth; London)
3. Solid State Chemistry -D.K. Chakraborty (New Age Int. Publication)
4. Physical Chemistry- Waller J. Moore
5. Principles of Polymer Chemistry Cornell, P. J. Flory (Univ. Press)
6. Handbook of Conducting Polymers Vol I & II" T A. Skolhia

III. CORE COURSE
MATERIAL CHEMISTRY

[CCCHE403]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100

Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

Upon completion of this course, the students will be able to understand

1. The mechanism of polymer material formation.
2. Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors.
3. Applications of Zeolites, metallosilicates, silicalites and related microporous materials.
4. Overview of nanostructures and nanomaterials.
5. The importance and applications of Industrial Chemicals like Industrial Gases and Inorganic compounds in uses.
6. The chemistry of dyes and their uses in various aspects of human civilization.

Course Learning Outcomes:

Upon successful completion of this course, the students should know:

1. Lattices and types of Crystal systems.
2. Inorganic and organic molecules as functionalized mesoporous materials
3. Inorganic solids/ionic liquids of technological importance.
4. The aspects of nanoscience, nanostructure and nanotechnology
5. The role of matrix in composites and reinforcements.
6. The Manufacture, application, analysis and hazards in handling the industrially important chemicals.
7. The Classification, Colour and Chemical constitution of various dyes.

Course Content:**UNIT I: Material Chemistry- Basics of crystalline solids**

(08 Lectures)

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism, twinning.

Silica based materials:

(08 Lectures)

Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications

Inorganic solids/ionic liquids of technological importance:

(08 Lectures)

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guest chemistry (elementary ideas).

UNIT II: Nanochemistry**Introduction to nanoscience, nanostructure and nanotechnology:**

(07 Lectures)

Basic idea; Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures, Spheroid, Wire, Rod, Tube, and Quantum Dot. Carbon nanotubes and inorganic nanowires. Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod and disc shapes nanoparticles.

Size dependent properties of nanomaterials:

(03 Lectures)

Basic idea with few examples only: Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colours (Blueshift & Red shift), Magnetic, thermal and catalytic properties.

Bio-nanomaterials:

(03 Lectures)

Basic Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisical nanomaterials, bionano composites.

Synthesis of Nanomaterials:

(05 Lectures)

Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

UNIT III: Composite materials:**(06 Lectures)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

UNIT IV: Industrial Chemicals**(06 Lectures)**

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

UNIT V: Chemistry of Dyes**(06 Lectures)**

Classification, Colour and chemical constitution, Mordant and Vat Dyes, Chemistry of dyeing, Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling), Triphenylmethane dyes -Malachite Green, Rosaniline and Crystal Violet, Phthalein dyes – Phenolphthalein and Fluorescein, Natural dyes –structure elucidation and synthesis of Alizarin and Indigo, Edible Dyes with examples.

Reference Books:

1. Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley 2003.
2. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning, 2002.
3. Adam, D.M. Inorganic Solids: *An introduction to concepts in solid-state structural chemistry*. John Wiley, 1974.
4. Zhen Guo and Li Tan, *Fundamentals and Applications of Nanomaterials*. 2009, Artech House, London Publication.
5. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
6. Polymer science, V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, New Age International (P)Ltd., 2015.
7. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
8. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
9. V. Gowariker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int. Publication, 2019.
10. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag, Germany, 2005.
11. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London, 2004
12. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005
13. Charles P. Poole and Frank J Owens, Introduction to nano technology, Wiley Interscience, 2003.
14. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.

IV. ELECTIVE COURSE-4A
INORGANIC PRACTICAL-4A

[EPCHE404A]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 6 Hrs) = 100

Pass Marks: = 45

(Credits: Theory-04, 60 Hours)

Course Content:

1. Qualitative separation and determination of the following pairs of metal ion using gravimetric and volumetric methods
 - a. $\text{Ag}^+(\text{g})$ and $\text{Cu}^{2+}(\text{v})$
 - b. $\text{Cu}^{2+}(\text{g})$ and $\text{Zn}^{2+}(\text{v})$
 - c. $\text{Fe}^{3+}(\text{g})$ and $\text{Ca}^{2+}(\text{v})$
 - d. $\text{Mg}^{2+}(\text{g})$ and $\text{Ca}^{2+}(\text{v})$
2. **Quantitative Analysis**
 - a. Analysis of alloys (brass, type metal, solder, gun metal) cement, steel using conventional chemical analysis/and physical techniques (if possible).
(Preferably one alloy and cement analysis may be carried out).
3. **Chromatographic Separations**
 - a. Cadmium and zinc
 - b. Zinc and magnesium.
 - c. Thin-layer / Paper chromatography-separation of nickel, manganese, cobalt and zinc. Determination of Rf values.
4. **Synthesis and characterization of following metal complexes:**
 - a. Sodium tetrathionate $\text{Na}_2\text{S}_4\text{O}_6$.
 - b. Metal complex of dimethyl sulfoxide: $\text{CuCl}_2 \cdot 2\text{DMSO}$
 - c. Synthesis of metal acetylacetone
 - d. Synthesis of copper and nickel Schiff base complexes.
 - e. Synthesis of copper and nickel dithiocarbamates
 - f. $[\text{Co}(\text{NH}_3)_5 \text{Cl}]\text{Cl}_2$
 - g. $[\text{Co}(\text{NH}_3)_5 \text{NO}_2]\text{Cl}_2$
 - h. $[\text{Co}(\text{NH}_3)_5 \text{ONC}]\text{Cl}_2$

Reference Books:

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS
2. Kettle, S. F. A. *Physical Inorganic Chemistry: A Coordination Chemistry Approach*, Springer, Berlin, Heidelberg (1996).
3. Drago, Russell S. *Physical Methods for Chemists* (2nd ed.), East West Press Pvt. Ltd. (2016).
4. Mabbs, F. E. & Machin, D. J. *Magnetism and Transition Metal Complexes*, Dover Publications; 2008 edition (2008).
5. Roberts, A. P. *Polyoxometalates: Properties, Structure and Synthesis*, Nova Science Publishers, Incorporated (2016).

OR ELECTIVE COURSE-4B
ORGANIC PRACTICAL-4B

[EPCHE404B]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 6 Hrs) = 100

Pass Marks: = 45

(Credits: Theory-04, 60 Hours)

Course Content:**1. Characterization of organic compounds**

It is expected to carry out separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid). Students should also check the purity of the separated components on TLC plates.

2. Extraction of Organic compounds from Natural Sources

- a. Isolation of Caffeine from Tea Leaves
- b. Isolation of Casein from milk (Some typical colour reactions of proteins).
- c. Isolation of lactose from milk (purity of sugar should be checked by LC and PC and Rf values reported).
- d. Isolation of Nicotine dipicrate from tobacco
- e. Isolation of β -carotene from carrots
- f. Isolation of Oleic acid from olive oil
- g. Isolation of (+)Limonine from citrus rinds

3. Multistep Synthesis of Organic Compounds

- a. Beckman rearrangement: Benzanilide from benzene
- b. Benzene \rightarrow Benzophenone \rightarrow Benzophenone oxime \rightarrow Benzanilide
- c. Benzoic acid rearrangement: Benzoic acid from benzoin
- d. Benzoin \rightarrow Benzoil \rightarrow Benzoic acid

4. Estimation of some organic compounds:

- a. Estimation of phenol/aniline using bromate bromide solution/or acetylation method
- b. Estimation of carbonyl group by using 2,4-dinitrophenyl hydrazine
- c. To determine the percentage or number of phenolic groups in the given sample by the acetylation method.

References:

- 1. Experimental Organic Chemistry H Dupon Durst. George W. Gokel, p.464 McGraw Hall Book Co., New York).

OR ELECTIVE COURSE-4C
PHYSICAL PRACTICAL-4C

[EPCHE404C]

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 6 Hrs) = 100

Pass Marks: = 45

(Credits: Theory-04, 60 Hours)

Course Content:**1. Conductometry**

- a. To titrate a mixture of HCl, CH₃COOH and CuSO₄ with NaOH.
- b. Conductometric titration of a mixture of halides (HCl, KCl and NH₄Cl)
- c. To determine the rate constant of saponification of an ester by NaOH.
- d. Determination of Critical Micelle Concentration (CMC) of a surface-active reagent (e.g. Sodium Lauryl Sulphate).

2. Determination of the equivalent conductance of the following strong electrolyte:

- a. KCl
- b. NaCl
- c. AgNO₃
- d. HCl
- e. KNO₃

3. Potentiometry

- a. To determine the solubility and solubility product of AgCl in water
- b. To determine the E⁰ of Zn/Zn⁺⁺, Cu/Cu⁺⁺ electrodes.
- c. To determine the basicity of a polybasic acid and its dissociation constant.
- d. To investigate the complex formed between CuSO₄ and NH₃.

4. Chemical Kinetics

- a. To study the kinetics of alkaline hydrolysis of an ester in an aquo-organic solvent system with respect to the effect of solvent composition and dielectric constant on the rate constant.
- b. To determine the rate constant of the reaction between K₂S₂O₈ and KI at two different temperatures and hence to determine the energy of activation of the reaction.

5. Thermochemistry

- a. Determination of the basicity of a polybasic acid.
- b. Determination of the heat of displacement of Cu by Zn from Cu²⁺ salt solution.
- c. Determination of the heat of hydration of Na₂SO₄ to Na₂SO₄.10H₂O.

6. Molar mass determination

- a. To determine the Molecular weight of a polymer (eg Polystyrene) from viscosity measurement.
- b. To determine the radius of a molecule from viscosity measurement.

V. PROJECT**DISSERTATION/ PROJECT/ TEACHING APTITUDE**

[PRCHE405]

Marks: 30 (MSE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100**Pass Marks: = 45****(Credits: Theory-04, 120 Hours)****(Credits: 04, 120 Hours)****Guidelines to Examiners for****End Semester Examination (ESE):**

The evaluation of the dissertation will be done in 100 marks (70 marks + 30 marks of the session). The sessional component will be evaluated by the concerned supervisor.

The end-term evaluation (70 marks) will be done by a board of examiners. The end term evaluation in 70 marks will include the literary and scientific presentation of the dissertation and the performance in the viva-voce.

Overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organization*
- *Application of the Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Course Objectives:

1. To develop research skills and scientific inquiry through independent investigations on a topic of problem in chemistry.

Course Outcomes:

On successful completion of this course, the student should know:

1. About conducting research with approved stages of research methodology in chemistry. A dissertation will enable students to further investigate and navigate different aspects and events of life through research.

PROJECT WORK

Each student has to submit three copies of hard-bound dissertation work (along with the raw data), duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the Department of Chemistry, Ranchi University, for evaluation (one month before the viva voce examination).

The paper may involve:

- (a) Laboratory research/ Field work/ Lab work related to the project.
- (b) Survey research, Case Study, or any other type of Chemical research
- (c) One Large study/ Experiment or several studies/ Experiments, depending on the objectives of the research.
- (d) Content must be typed in Font: Times New Roman with Line Spacing: 1.5 and Font Size 12 points.

Presentation of project work in the seminar on the assigned topic in the P.G. Department of Chemistry, Ranchi University, Ranchi & open viva there on.

Topics: As decided by the Supervisor/Guide

Teaching Aptitude: Only selected candidates, in alternative to the Dissertation, may be provided duty to teach the assigned topics in selected colleges. The performance may be evaluated based on the organized feedback for the candidate.