2-YEARS 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

UNIVERSITY DEPARTMENT OF CHEMISTRY

Ranchi University, Ranchi-834008 (Jharkhand)

E-mail : chemistry@ranchiuniversity.ac.in & pgchemistryru2@gmail.com

Ref. No. RU /Chem / .... Date :........................

Members of the Board of Studies of NEP FYUGP & PG Curriculum of Chemistry As per the Guidelines of the Ranchi University, Ranchi

1. **Chairman –**
   Dr. Anil Kumar Delta
   Associate Professor & Head,
   University Department of Chemistry, Ranchi University, Ranchi

2. **External Members:**
   i. **Prof. Sanjoy Misra**
   Rtd. Head, University Department of Chemistry,
   Ranchi University, Ranchi
   ii. **Prof. (Mrs) Sumit Mishra**
   Head, Department of Chemistry,
   BIT,Mesra

3. **Internal Members-**
   i. **Dr. U. R. Sen**
   Associate Professor,
   Department of Chemistry, St. Xavier College, Ranchi
   ii. **Dr. S.K. Sengupta**
   Assistant Professor,
   Department of Chemistry, Gossner College, Ranchi
   iii. **Dr. Smriti Singh**
   Assistant Professor,
   University Department of Chemistry, Ranchi University, Ranchi
   iv. **Dr. Neelam**
   Assistant Professor,
   University Department of Chemistry, Ranchi University, Ranchi
   v. **Dr. Neeraj**
   Assistant Professor,
   University Department of Chemistry, Ranchi University, Ranchi
   vi. **Dr. Shilpi Singh**
   Assistant Professor,
   Department of Chemistry, Doranda College, Ranchi
   vii. **Shri Shubhankar Aich**
   Assistant Professor,
   Department of Chemistry, Marwari College, Ranchi
   viii. **Dr. Anil Kumar Pandey**
   Assistant Professor,
   Department of Chemistry, J.N. College, Dhurwa, Ranchi
   ix. **Dr. Namrata Sinha**
   Assistant Professor,
   Department of Chemistry, Ranchi Womens' College, Ranchi

4. **Research Scholars:**
   i. **Rekha Kumari**
   Ph.D. Scholar, SRF,
   Department of Chemistry, R.U.
   ii. **Shuvajit Banerjee**
   Ph.D. Scholar, JRF,
   Department of Chemistry, R.U.

Chairperson
HEAD
Department of Chemistry
Ranchi University, Ranchi

Approval by the Members of the NEP Implementation and Monitoring Committee of Ranchi University, Ranchi

The prepared Curriculum of the Master's Degree has been approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the Head of the Department; it will be offered to the Students of the 1-year and 2-year Postgraduate Programme. It is implemented from the 1st Semester of the Academic Session 2025-26 and onwards.

Member Secretory

Table of Contents

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/LOCF/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 (2^{nd}, 3^{rd} and 4^{th}) **provided he/she has passed at least in <u>3 courses</u> 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. <u>However, it will be mandatory to secure minimum pass marks in the course before exit from the PG Programme.</u>
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.

--- x ---

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

--- x ---

FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **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. [5x1=5]
   i. ....
   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**:

Subject/ Code

F.M. =70 **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. [5x1=5]
   i. ....
   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 [FCCHE101]
FOUNDATION 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 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: Stereochemistry and Bonding in Main Group Compounds (05 Lectures)

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

UNIT II: 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.

UNIT III: 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 IV: 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 V: 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 VI: 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 sugarsand 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 VII: 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 VIII: 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 [CCCHE102]
MOLECULAR SPECTROSCOPY

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 >C=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 II: 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 III: 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 IV: 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 Characterisation 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. William 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 [CCCHE103]
RESEARCH METHODOLOGY

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. To introduce students to the basics of research and scientific inquiry
2. To enable students to identify and define research problems
3. To familiarise 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 organisation, 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. Kerlinger, Fred N., Foundation of Behavioural Research, Holt, Rinehart and Winston Publishing.
5. Ahuja, Ram. Research Methods, Rawat Publications.

IV. CORE COURSE [CCCHE104]
PHOTOCHEMISTRY

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 dimerisation of diphenyl methanone (benzophenone), Photoisomerisation 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 [CCCHE105]
PRACTICAL-1

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 for

End 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 acids 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-}, $C_2O_4^{2-}$
(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) Manganese in steel by the sodium bismuthate method.

III. Preparation of Inorganic Complexes
(i) $[Cu(NH_3)_4]SO_4.H_2O$
(ii) $K_3[Fe(C_2O_4)_3]$
(iii) Prussian Blue, Turnbull's Blue
(iv) $[Ni(NH_3)_6]Cl_2$
(v) $[Ni(dmg)_2]$
(vi) Reineckle's Salt $NH_4[Cr(NCS)_4(NH_3)_2].H_2O$

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, Tinnesand (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 H_2
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 quantisation, wave-particle duality (de-Broglie's hypothesis), Planck's Quantum theory. The uncertainty principle, the wave function, wave function and its interpretation, conditions of normalisation 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 $R_{(r)}$, $\Theta_{(\theta)}$ & $\Phi_{(\phi)}$ (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, generalised 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 d^n 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 [CCCHE202]
MECHANISM IN ORGANIC 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:
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's 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)**
   OsO_4, $KMnO_4$, SeO_2, DDQ, PCC, PDC, TEMPO, NaOCl, MnO_2, Jones reagent, Collins reagent.

2. **Reducing Agents** **(08 Lectures)**
   $NaBH_4$, $LiAlH_4$, DIBAL-H, BH_3, N_2H_2, 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 Stykes.
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 Publishers, (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. 0. House, *Modern Organic Reactions*, Benjamin.
7. R. 0. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, Blackle 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 [CCCHE203]
ANALYTICAL 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 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 decomposition. 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, the Normal error curve and its equation. Useful statistical tests with equations, test of significance, the F-test, Q-test, the Student's 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 foodstuffs. 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 wastewater, 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 techniques 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 radioimmunoassay (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 theromogravimetric 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.

IV. CORE COURSE [CCCHE204]
ENVIRONMENTAL 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:
On completion of this course, the students will be able to understand:
1. The importance of Environment and its connect between various forms of life.
2. The role of abiotic components in sustaining life.
3. 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 the Hydrosphere, Soil and 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's atmospheric system, vertical stability atmosphere. Biogeochemical cycles of C, N, P, S and 0. Biodistribution of elements.

UNIT II: Hydrosphere (15 Lectures)
Chemical composition of water bodies-lakes, streams, rivers and wetlands 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- fertilisers, 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 the atmosphere, smog formation, oxides of N, C, S, 0 and their effect, pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons. Greenhouse 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 Pubilshers.
3. Environmental Chemistry, A. K. De, Wiley Easlem.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
5. Standard Method of Chemical Analysis, FJ. 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. Crealchman, 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 [CPCHE205]
PRACTICAL-2

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 the percentage composition of a mixture of two liquids by the Ostwald tube.
(b) To determine the parachor of – CH_2, 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 the water equivalent of a calorimeter
(b) Determination of the Heat of Neutralisation of:
(i) Strong acid and strong base (HCl and NaOH)
(ii) Weak acid and strong base (NaOH and CH3COOH).
(c) Determination of the Heat of Solution of Potassium Nitrate
(d) Determination of the basicity of succinic Acid by the 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 Coefficient
(a) Determination of the partition coefficient of:
(i) Benzoic acid between water and Benzene
(ii) Iodine between water and carbon tetrachloride
(b) Determination of the Composition of Cupric-ammine sulphate formed between $CuSO_4$ and NH_3
(c) Determination of the equilibrium constant for the reaction $KI+I_2=KI_3$

SEMESTER III

I. CORE COURSE [CCCHE301]
INDIAN KNOWLEDGE SYSTEM & METALLURGY

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 the Stone Age to the Metal Age, including discoveries of tin, gold, silver, brass, bronze and iron.
3. Analyse 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. Analyse 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 (Pañcīkaraṇa), 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 the Stone Age to the 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 the 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, Ayurveda 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 Rigveda*
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 [ECCHE302]
BIO-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:
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 their 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 bioinorganic chemistry. Geochemical effect on the distribution of metals. Essential and trace metals. Role of metal 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, Hemoglobin, Myoglobin, Storage and transfer of iron. Role of Ca^{2+} in blood clotting, stabilisation of protein structures and structural role (bones).

UNIT II: Bioenergetics and ATP Cycle **(05 Lectures)**
DNA polymerisation, glucose storage, metal complexes in the transmission of energy; chlorophylls, photosystem I and photosystem II in the 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 Koshtand'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 isomerisation and rearrangement reactions. Enzyme-catalysed 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, lipolc acid, vitamin B_{12}. 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 immobilisation of enzymes, effect of immobilization on enzyme activity, application of immobilised 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 a mechanochemical system.

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

Structure and functions of the cell membrane, ion transport through the 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 Hail.
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 0. 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. MeUler, Academic Press.

III. CORE COURSE [CCCHE303]
GROUP THEORY & TRANSITION

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 Cn, Cnv, Cnh. Dnh 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 Cn, Cnv, Cnh. Dnh 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: Advanced Chemistry of d- and f-block elements (10 Lectures)
Crystal field theory and splitting in Oh, Td, D4h and C4v 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. 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. Hatfield, 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. Saundersand 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 [CCCHE304]
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 planar 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 polarisation 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 vibration 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

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 - El, Cl, 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. Orehin, 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. 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, 1. Fleming, Tala McGraw-Hill.

V. CORE COURSE [CCCHE305]
PRACTICAL-3

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 an electrochemical cell as an acidic electrolyte, can be tested. A simple electrolytic cell can be assembled with a vinegar solution.
4. pH indicators as in the 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 involves the preparation of a complex with urea and the separation of linoleic acid. Isolation of eugenol from cloves. Isolation of (+) limonine from citrus rinds

3. Experiments I (Lab-work)

Group A: Estimation of the following in water

(a) Ca (b) Fe (c) Mg
(d) Chemical oxygen demand (COD)
(e) Biochemical oxygen demand (BOD) &
(f) Dissolved oxygen (DO)

Group B: Analysis of soil for the following

(a) Ca (b) Mg (c) Total nitrogen
(d) Carbonate (e) Organic matter (f) Ammonia & (g) Nitrate nitrogen

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 [ECCHE401A]
INORGANIC CHEMISTRY-1A

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 the 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 polymerisation 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 (Wilkinsons 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. Hegsdus, J.R. Norton and R.G. Pinke, University Science Books.
2. The Organometallic Chemistry o1 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 [ECCHE401B]

ORGANIC CHEMISTRY-1B

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 Valence 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 the 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 Gibbs' 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, Tunnelling 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 the 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 organisation 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 and Progestrone.

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. Modelling, 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. Davision, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Logman, Essex.

OR ELECTIVE COURSE-1C [ECCHE401C]

PHYSICAL CHEMISTRY-1C

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 the partition function.
2. The differences between metallic conductors, insulators and semiconductors.
3. The Interconversion 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: (14 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. Equilibrium constant and partition function. Third Law of Thermodynamics and Partition Function. Applications of the partition function of monotonic gases; Partition function for diatomic molecules. The Bose-Einstein statistics & Fermi-Dirac statistics for metals.

UNIT II: Metallic bonds (08 Lectures)

Free electron theory, band theory, Fermi level, Brillouin zone, wave function for electrons in solids, metallic conductors, insulators, 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 coordinate, Transmission coefficient, non-adiabatic reaction.

UNIT IV: Electrochemistry (10 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.

UNIT V: Corrosion (05 Lectures)

Introduction, Factors affecting corrosion, homogeneous theory, electrolytic theory of corrosion, Corrosion inhibitors, Passivity, Types of corrosion, special attention to rusting and its influence on the economy of the world, Corrosion monitoring and prevention methods.

UNIT VI: 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 [ECCHE402A]
INORGANIC CHEMISTRY-2A

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 Biomineralization.
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, the effect of Metal deficiency and disease and the 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 Biomineralisation (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.

(A) Molecular recognition: Molecular receptors for different types of molecules, including arisonic substrates, design and synthesis of coreceptor molecules and multiple recognition.

(B) Supramolecular reactivity and catalysis.

(C) Transport processes and carrier design.

(D) Supramolecular devices. Supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Some examples 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. 0.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 [ECCHE402B]

ORGANIC CHEMISTRY-2B

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 and structure of Vitamins.

Course Learning Outcomes:

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

1. The Chemistry of Pericylic 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 affecting 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 periycyclic 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 cheleotropic 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 cyclisation reactions and cycloaddition reactions.

UNIT III: Small ring Heterocycles (09 Lectures)

Three, four and 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, B_1, B_2, B_6, 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 Chemisiry, Q. R. Newkome and W. W. Paudler, Wiley-inter Science.
8. An introduction to the Heterocyclic Compounds. Linds, R. M. Acheson, JohnWiley.
9. Organic Chemistry, Vol 2, l. 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 [ECCHE402C]
PHYSICAL CHEMISTRY-2C

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. Kinetics of surface processes. Surface active agents or surfactants.
2. Factors related to the Kinetics of Condensed Phase Reactions

Course Content:

UNIT I: Superconductivity (10 Lectures)
Superconductivity, Meissner effect, microscopic theory of superconductivity, conventional organic and high temperature superconductors, fullerenes, applications of superconductors. Transformation in crystals - thermodynamics of transformation, order-disorder transitions, martensitic transition, polymorphic transformation

UNIT II: Specific heat of solids (07 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 the thermodynamic barrier.

UNIT III: Surface chemistry (18 Lectures)
Surface phenomena: Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micelle concentration (CMC), Krafft temperature, Factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization, solubilization, microemulsions, reverse micelles, surface films (electrokinetic phenomena), catalytic activity at surfaces. The BET isotherm for multilayers & its derivation, the measurement of the Surface area of adsorbents. Gibbs adsorption equation. Kinetics of surface processes, unimolecular and bimolecular surface reactions, electrocapillarity, electrokinetic effects, statistical mechanics of adsorption. Catalytic activities at surfaces.

Preparation & purification of sols. General properties of colloidal solutions, Coagulation, Electrical properties, and stability of colloids. Cataphoresis, Zeta potential, Micelles. Peptization theory. Emulsions and colloids around us.

UNIT IV: Polymers: (15 Lectures)
Polymer solution, thermodynamics of polymer dissolutions, Flory-Huggins Theory of Polymer Solutions. molar mass and molar mass distribution (Number Average and Weight Average Molecular weight), methods of measuring molar masses-Molecular Weight Determination by Light scattering, End-group analysis, Viscosity, Applications of FTIR, UV-visible, NMR and Mass Spectroscopy for identification of polymers.

Polymeric Structure and Property Relationship
Structure of polymers - Linear, branched, cross-linked and network polymers, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature. Ziegler-Natta, Metallocene and others.

Electrically conducting polymers: Electrically conducting polymers, electrochemical polymerisation, band structure of polymers, mechanism of conduction in polymers, doping of polymers, application of conducting 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 (10 Lectures)
Rate-determining steps in diffusion-controlled reactions and activation-controlled reactions, Stokes-Einstein equation and dependence of rate constant on coefficient 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. Barrow, G. M., *Physical Chemistry* 5th Ed., Tata McGraw-Hill: New Delhi (2006).
5. Physical Chemistry- Waller J. Moore
6. Principles of Polymer Chemistry Cornell, P. J. Flory (Univ. Press)
7. Handbook of Conducting Polymers Vol I & II" T A. Skolhia
8. Laidler K.J. (2003), Chemical Kinetics, 3rd Edition, Pearson Education India.
9. Surface Chemistry, Gurdeep Raj, Goel Publishing House, Merrut, India

----

III. CORE COURSE [CCCHE403]
MATERIAL CHEMISTRY

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. The concept of Smart Material and their applications.
3. Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors.
4. Applications of Zeolites, metallosilicates, silicalites and related microporous materials.
5. Overview of nanostructures and nanomaterials.
6. The importance and applications of Industrial Chemicals like Industrial Gases and Inorganic compounds in their uses.
7. The chemistry of dyes and their uses in various aspects of human civilisation.

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 (05 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.

Smart Materials: (06 Lectures)

General Characteristics of Metals, Ceramics, Polymers, Composites and Smart Materials. Classification of Smart Materials. General overview of a few smart materials (eg. Piezoelectric materials, Shape memory alloys, Magnetic shape memory alloys, Shape memory polymers, PH sensitive polymers)

Silica-based materials: (05 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 the percentage of surface atom and surface to volume ratio of spherical, wire, rod and disc-shaped 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 artificial 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, chlorine, 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.

Inorganic solids: Synthesis of Zeolite, Silicones.

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. Gowriker, 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, Willey-VCH Verlag, Germany, 2005.
11. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, 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 [EPCHE404A]
INORGANIC PRACTICAL-4A

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. Ag^{+}(g) and Cu^{2+}(v)
   b. Cu^{2+}(g) and Zn^{2+}(v)
   c. Fe^{3+}(g) and Ca^{2+} (v)
   d. Mg^{2+}(g) and Ca^{2+} (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 characterisation of the following metal complexes:**
   a. Sodium tetrathionate $Na_2S_4O_6$.
   b. Metal complex of dimethyl sulfoxide: $CuCl_2$.2DMSO
   c. Synthesis of metal acetylacetonate
   d. Synthesis of copper and nickel Schiff base complexes.
   e. Synthesis of copper and nickel dithiocarbamates
   f. $[Co(NH_3)_5\ Cl]Cl_2$
   g. $[Co(NH_3)_5NO_2]Cl_2$
   h. $[Co(NH_3)_5ONC]Cl_2$

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 [EPCHE404B]

ORGANIC PRACTICAL-4B

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. **Characterisation 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 → Benzophenone → Benzophenone oxime →Benzanilide
   c. Benzilic acid rearrangement: Benzilic acid from benzoin
   d. Benzoin → Benzil → Benzilic 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 [EPCHE404C]

PHYSICAL PRACTICAL-4C

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, CH_3COOH and $CuSO_4$ with NaOH.
    b. Conductometric titration of a mixture of halides (HCl, KCl and NH_4Cl)
    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. $AgNO_3$
    d. HCl
    e. KNO_3
3. **Potentiometry**
    a. To determine the solubility and solubility product of AgCl in water
    b. To determine the E^0 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 $CuSO_4$ and NH_3.
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 $K_2S_2O_8$ 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 Cu^{2+} salt solution.
    c. Determination of the heat of hydration of Na_2SO_4 to $Na_2SO_4.10H_2O$.
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 [PRCHE405]

DISSERTATION/ PROJECT/ TEACHING APTITUDE

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 organisation*
- *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.
