Nehru Gram Bharati
(Deemed to be University)

KOTWA-JAMUNIPUR-DUBAWAL
PRAYAGRAJ-221505
UTTAR PRADESH

Department of Chemistry

Syllabus for the

Master of Science in chemistry
(A Four Semester Course)
Based on Choice Based Credit System (CBCS)
Commencing Session: 2019–2020

ABOUT THE UNIVERSITY

Nehru Gram Bharati (Deemed to be University) occupies an esteemed place among the rural universities of India for over decades now. Established on 27th June 2008, it is one of the promising institutes in the State of Uttar Pradesh situated at the bank of river Ganges. It was basically conceived by our Ist Prime Minister of India, Late Pt. Jawahar Lal Nehru, who laid the foundation stone of Nehru Gram Bharati on 26th July 1962 in the village of Rishi Durvasha Ashram, Kotwa-Jamunipur, Dubawal Complex of his phulpur constituency in Allahabad District. His dream was translated into reality by Sri J.N. Mishra, who had a clear vision and dedication to the cause of upliftment of rural masses through education.

As on date, the campus has emerged as a prominent establishment of professional, technical education and traditional education for meeting the aspirations of youth from rural as well as urban areas. To begin with Rajiv Gandhi Degree College was established in the year 1996 and upgraded to Rajiv Gandhi Post Graduate College from the academic session 2000-01 which subsequently merged into the Nehru Gram Bharati (Deemed to be University) in 2008-09 after University Grants Commission recommended to the Ministry of Human Resource & Development for granting it Deemed to be University Status. The MHRD notified vide its gazette Notification no. F.9-42/2005-43(A) dated as 27th June 2008 bestowing the Deemed to be University status to Nehru Gram Bharati

The Nehru Gram Bharati (Deemed to be University) is composed of six campuses encircling approximately 76 acres of land spread over within a radius of about 5 Kilometers. The campuses are as under:

Nehru Gram Bharati (Deemed to be University), Jamunipur Main Campus: The lush green campus has buildings for Administrative Office, Central Library, Faculty of Teacher Education, Arts, Science & Commerce. The Undergraduate Courses viz., Bachelor of Arts (in the subjects Ancient History, Pol. Science, Hindi, Geography, Education, Sanskrit, English, Sociology, Home Science, Economics, Music & Philosophy), Bachelor of Commerce, Bachelor of Science (In Physics, Chemistry, Zoology, Mathematics & Physics), Bachelor of Education(B.Ed.), Bachelor of Special Education (Hearing Impairment), Diploma in Special Education(D.Ed.Spl.Ed.[HI]), Bachelor of Elementary Education (B.El.Ed.), Diploma in Elementary Education (D.El.Ed.) are being offered in this campus. The Post Graduate Courses viz., Master of Arts (In Ancient History, Pol. Science, Hindi, Education, Sanskrit, English, Economics, Sociology, Home Science, Philosophy & Geography), Master of Commerce, Master of Science (In Physics, Chemistry, Zoology, Mathematics and Botany), Master in Education (M.Ed.), Master of Special Education in Hearing Impairment (M.Ed.Spl.Ed.[HI] are being offered in the campus.

Nehru Gram Bharati (Deemed to be University), Shashi Campus (Research Centre): The Research Centre is located at Anjaneya Parishar, Jhuthi Tali, Prayagraj to conduct research programmes in various available disciplines for Ph.D. Degree. The departments of Journalism & Mass Communication and Social Work also share a part of the building offering Post Graduate Diploma in Journalism & Mass Communication (PGDJMC), Bachelor of Arts (Journalism & Mass Communication), Master of Arts (Journalism & Mass Communication), & Master of Social Work.

Nehru Gram Bharati (Deemed to be University), Kamal Goindi Campus : The campus is situated at a distance of 500 mts. from the Jamunipur main Campus. It houses the Department of Music and Performing Arts and Library & Information Science offering the degrees of Bachelor in Performing Arts (Vocal & Tabla), Masters in Performing Arts (Vocal & Instruments), Bachelor & Masters degree in Library and Information Science.

Nehru Gram Bharati (Deemed to be University), Hanumanganj Campus: The Faculty of Law is located at a distance of around 04 Kms from Jamunipur Main Campus on Prayagraj-Varanasi route offering LL.B. (3 years), B.A.LL.B. (Integrated 5 years) and LL.M. Courses. Department of Computer Application is also a part of Hanumanganj Campus and offers B.C.A., M.C.A. and PGDCA Courses.

Nehru Gram Bharati (Deemed to be University), Civil Lines Campus: The Department of Management is placed at Civil Lines Campus of the Deemed to be University offering B.B.A. and M.B.A. Courses.

Nehru Gram Bharati (Deemed to be University), Sarpatipur Campus: The Nehru Gram Bharati proposes to start medical education wing in near future.

ABOUT THE DEPARTMENT

The Department of Chemistry is one of the oldest and most prominent departments of NGB. The department was established in 2008 and is placed in Jamunipur campus of Nehru Gram Bharati (Deemed to be University). It started functioning in 2008-2009.

This department earned significant popularity on national/international scenario under the able guidance and headship of Dr S.C. Tiwari, Pro vice chancellor, NGB (DU). The Chemical Laboratories of NGB formed the nucleus of University Department of Chemistry.

The Department offers Credit based elective course system (ECS) in UG and CBCS in PG programme to provide an opportunity to student to choose courses from the syllabus and flexibility to the programme structure. It also ensures that the student gets a strong foundation in the subject and gains in-depth knowledge.

THE VISION

The vision of the university is to nurture and promote youth especially from rural area by providing high quality education and training in keeping with the promise of Late Pt. Jawahar Lal Nehru. To be a department of excellence in chemistry education, widely known for development of competent, socially responsible leader, entrepreneurs and developer of technology for welfare of human being.

THE MISSION

- To impart establishment and contemporary knowledge.
- To synchronize concepts, logic and skills for effective decision-making.
- To promote, inspire and nurture the fundamentals of chemistry through UG and PG courses offered.

- To emphasize on inculcating initiative for entrepreneurship generating self-employment and national wealth.
- To promote awareness towards social issues through various group activities and events.

SHORT/LONG TERM PLAN

- Identification of new programme.
- To introduce and establish new bachelor of sciences programme in chemistry.
- Instituting new integrated M.Sc.-Ph.D programme.
- Collaboration with universities/research institute/others industries.
- Useful departmental addition to existing syllabus.
- To introduce useful employment oriented activity Value added/add-on courses.

Programmes Duration and Design

At undergraduate level department offers courses of study for students from both streams viz. Mathematical sciences and Biological sciences. The undergraduate degree courses in chemistry is a six semester spread over three years academic years. At P.G. level, specialization is available in organic, inorganic and physical and M.Sc. degree is a four-semester course spread over two years. The department also offers Ph.D in science in Chemistry.

ORDINANCE AND REGULATIONS FOR ALL POST GRADUATE PROGRAMMES

ORDINANCE

1. **The Degree of Master of Arts/Science/Social Science/Commerce/Law/Teacher's Education**

The Nehru Gram Bharati (Deemed to University) may confer the Degree of Master's Programme on Such candidates who, being eligible for admission to the Post Graduate Degree Programme, have received regular instruction in the prescribed course of study, passed successfully relevant examinations and being otherwise suitable by virtue of their character, have fulfilled such other condition as may be laid down from time to time by the appropriate authorities.

2. **The Curriculum and Duration of Studies**

A. (i) The Curriculum of study of the Master Degree shall comprise of courses set out in Annexure B.
(ii) The Departmental Committee shall prescribe the detailed content of various of study, if required before the beginning of each session. The Departmental Committee can make changes in the optional papers/subjects, subjects to the availability of teaching facility/

faculty.

B. The curriculum of study for the Master Degree shall be spread over four Semesters having 80 credits (each semester of 20 credits).

3. Requirement for Admission

1. Registration:

I. Candidates of Master Degree shall first be admitted to the first semester upon the reopening of the University after summer vacation every year.

II. **Subsequent Registration**

A candidate, who fails to clear a regular course of study during any of the second, third and fourth semesters may be registered in the appropriate term of any subsequent year to the semester concerned but within such time as enables him, to compete the study of all semester comprising Master Degree Programme within a maximum period of four years from the date of his/her registration for the first semester.

2. Minimum Qualification For Admission

Admission to the Master Degree Programme of study shall be open to those candidates who have passed the 3 Year Graduate Degree Examination of this University or such examination of any other University or Institution after Graduation under 10+2+3 pattern as recognized by the University. Admission shall be made according to merit subject to the fulfillment of eligibility requirement as determined by the University and availability of seats in the Master courses.

3. Conditions of Admission:

I. No application for registration to the First Semester shall be entertained unless it is accompanied by

a. A duly migration of scholastic record of the candidate, commencing from the graduation or equivalent examination.

b. Original migration of a candidate who has been a regular student in any Institution at any time prior to making application for registration in the Faculty.

c. Original migration certificate if the candidate is not enrolled in this University or if enrolled, his enrollment has been cancelled. Provided that if a candidate is unable to produce any of the documents other than the marks- sheet of the graduate examination at the time of seeking admission in the concerned Faculty before admission committee, he shall undertake to submit them within one month or within such further period as the University authorities may prescribed; and the admission, if any of such candidate shall until the submission of the aforesaid documents, be deemed to be provisional.

II. Candidate shall give also a written undertaking to the effect that:

a. He/She shall exclusively devote his/her time to the study of courses prescribed for Master Degree and in particular he/she shall not offer any other course leading to a

degree of any description whatsoever, not shall he/she undertake any remunerative work, though with the prior permission of the Faculty, he/she may join certificate of or diploma courses in any foreign language.

b. He/She shall abide by the provision of NGB (DU) Act, Statutes, Ordinances, Regulations and Rules that are framed or may be framed there under and the orders of Officers and authorities of the University and the concerned Faculty from time to time

4. **Fees:**
The students pursuing Master Degree Programme of study shall have to pay fee as may be prescribed by the University from time to time.

REGULATIONS

1. Master Degree Programme has been divided in fours semesters in two years, this is a full time course study. The odd semester would run between July to December and even semester between January to June. Two consecutive (one odd + one even) semester constitute one academic year.
2. There will be minimum 18 and maximum 24 papers /courses in all in the whole programme. Besides, there would also be one course on **Dissertation and Viva- Voce.**
3. The course has 4 components: Core courses, Elective course, Skill Development and Inter-disciplinary course.
4. Each Core course has equal weightage. Each core course will have 75 marks or 3 credits. Elective and Inter-disciplinary course will have 3 credits, whereas Skill Developments course will have 2 credits. Tutorial classes shall be conducted as per the need of course.
5. The core courses are compulsory to all students in all four semesters. The fourth (Elective course) paper and fifth (Skill Development course) paper will be opted by the students of same Department. However, the sixth (Inter-disciplinary course / University elective course) paper of each semester will be opted by the students of other Departments only.
6. In the beginning of the **Se**mester III, the Department would announce the available specialization group/ course in the Elective Group to the students for the current session. The choice of elective group/course in the semester will be limited to those announced by the Department. Because of infrastructural and Faculty limitations, the Department may put a cap on the number of students in an elective group/course.
7. Each semester shall have minimum 90 teaching days, exclusion of holidays, admission and examinations.

Preamble of the Syllabus

Master of Science (M.Sc.) in Chemistry is a post-graduate course of Nehru Gram Bharati (Deemed to be University). The curriculum is prepared by following the prospectus of various national and international standards. The choice based credit system (CBCS) to be implemented through this curriculum would allow students to develop a strong footing in the fundamentals and to specialize in the disciplines of his/her liking and abilities. The students pursuing this course would have to develop in-depth understanding of various aspects of chemistry. The aim of this course is to provide conceptual understanding, development of experimental skills, designing and implementation of novel synthetic methods, developing the aptitude for academic and professional skills, acquiring the basic concepts for structural elucidation with

hyphenated techniques, understanding the fundamental chemical and biological processes and rationale towards computer. The project/Dissertation introduced in the curriculum will motivate the students to pursue the research and find a job in reputed pharmaceutical and other industries in India and abroad.

PROGRAMME DETAILS

MASTER OF SCIENCE (M.Sc.) in CHEMISTRY

PROGRAMME STRUCTURE

M.Sc. Chemistry (Under CBCS Pattern) with effect from Session 2021-2022

Semester I

Sl. No.	Paper	Code	Type	Title of the Paper	Credi	L+T+P	ESE.	IA	Total Mark
1.	Paper-I	CHE101	Core-1	Inorganic Chemistry- I	03	2+1+0	45	30	75
2.	Paper-II	CHE102	Core-2	Organic Chemistry- I	03	2+1+0	45	30	75
3.	Paper-III	CHE103	Core-3	Physical Chemistry- I	03	2+1+0	45	30	75
4.	Practical - I	CHEL1	Lab-1	Practical	03	0+0+3	45	30	75
5.	Paper-IV	CHE104 - 106	Elective - I		03	2+1+0	45	30	75
6.	Paper-V	CHE107	SD-1	Laboratory techniques and data interpretation	02	2+0+0	30	20	50
7.	Paper-VI	CHE108	UE-1	Polymer Chemistry	03	2+1+0	45	30	75
Total					20				500

Elective I: One out of three listed below:

CHE104: Solvent Extraction and Chromatography
CHE105: Introduction to Analytical Chemistry I
CHE106: Computer Applications in Chemistry

Note: The Practical Exam shall consist of three papers (each from core papers), each of Six hour's duration, suitably spread over two or three days and shall be at the end of Semester.

Semester II

Sl. No.	Paper	Code	Type	Title of the Paper	Cre	L+T+P	ESE.	IA	Total Mark
1.	Paper-I	CHE201	Core-4	Inorganic Chemistry- II	03	2+1+0	45	30	75
2.	Paper-II	CHE202	Core-5	Organic Chemistry- II	03	2+1+0	45	30	75
3.	Paper-III	CHE203	Core-6	Physical Chemistry- II	03	2+1+0	45	30	75
4.	Practical - II	CHEL2	Lab-2	Practical of Core Papers	03	0+0+3	45	30	75
5.	Paper-IV	CHE204 - 206	Elective - II		03	2+1+0	45	30	75
6.	Paper-V	CHE207	SD-2	Analysis and determination Lab	02	2+0+0	30	20	50
7.	Paper-VI	CHE208	UE-2	Organic Chemistry (Applied Aspects Only)	03	2+1+0	45	30	75
Total					20				500

Elective II: One out of three listed below:

CHE204: Forensic Analysis
CHE205: Catalysis and Green Chemistry
CHE206: Introduction to Analytical Chemistry II

Note: The Practical Exam shall consist of three papers (each from core papers), each of Six hour's duration, suitably spread over Two/three days and shall be at the end of Semester.

Semester III

Sl. No.	Paper	Code	Type	Title of the Paper	Credit	L+T+P	ESE	IA	Total Mark
1.	Paper-I	CHE301	Core-7	Specialization Paper-I (I/O/P)*	03	2+1+0	45	30	75
2.	Paper-II	CHE302	Core-8	Specialization Paper-II (I/O/P)*	03	2+1+0	45	30	75
3.	Paper-III	CHE303	Core-9	Specialization Paper-III (I/O/P)*	03	2+1+0	45	30	75
4.	Practical - III	CHEL3	Lab-3	Practical (I/O/P)*	03	0+0+3	45	30	75
5.	Paper-IV	CHE304 - 306	Elective III		03	2+1+0	45	30	75
6.	Paper-V	CHE307	SD-3	Hand Made Soap/Detergent Making	02	2+0+0	30	20	50
7.	Paper-VI	CHE308	UE-3	Environmental Chemistry	03	2+1+0	45	30	75
Total					20				500

*The choice of Specialization in the semester will be subjected to the infrastructural and faculty limitations

Elective Papers III: One out of three listed below:

CHE304: Chemistry of Macromolecules
CHE305: Nanocatalysis
CHE306: Nuclear Chemistry and Radioanalysis

Note: The Practical Exam in each specialization shall consist of three papers (each from core papers), each of Six hour's duration, suitably spread over two/three days and shall be at the end of Semester.

Semester IV

Sl. No.	Paper	Code	Type	Title of The	Credit	L+T+P	ESE.	IA	Total Mark
1.	Paper-I	CHE401	Core-4	Specialization Paper-IV (I/O/P)*	03	2+1+0	45	30	75
2.	Paper-II	CHE402	Core-5	Specialization Paper-V (I/O/P)*	03	2+1+0	45	30	75
3.	Paper-III	CHE403	Core-6	Specialization Paper-VI (I/O/P)*	03	2+1+0	45	30	75
4.	Project Work	CHEL4	Project/ Dissertation		03	0+0+3	45	30	75
5.	Paper-IV	CHE404-406	Elective IV		03	2+1+0	45	30	75
6.	Paper-V	CHE407	SD-2	Industry visit/Field work	02	2+0+0	30	20	50
7.	Paper-VI	CHE408	UE-2	Nano chemistry	03	2+1+0	45	30	75
Total					20				500

Elective Papers IV:

CHE404 Cheminformatics
CHE405: Functional Organic Materials
CHE406: Analytical Electrochemistry

Note: The Practical Exam in each specialization shall consist of three papers (each from core papers), each of Six hours duration, suitably spread over two/three days and shall be at the end of Semester.

Industrial Visit/Internship:

Industrial Visit (7-15 days)/Field work are proposed in and around prayagraj for the students. Each student has to give a power point presentation in the department. Each presentation will be of 30 minutes duration and has to submit a report. Marks will be on the basis of presentation and report.

Project/Dissertation (CHE-L4):

Individual faculty members will float stipulated number of projects at the end of III SEM. Students have to consult respective faculty members and select projects. More than one student can work under a single project based on nature of the project. Guide allotment for MSc project will be based on choice cum merit.
Once guide allotment (either single or more than one guide) is declared, student has to submit research proposal and give a presentation, either individually or one member from the group. Research proposal and presentation carries 10 marks. Students will be periodically assessed for their project work by individual faculty member or group of faculty members. The final submission of the research project, i.e., small thesis, presentation and comprehensive viva carries 35 marks.

Note:

1. Student should submit 3 copies of the final research project copy in hard binding format with all declarations and signatures.
2. For referencing any ACS journal pattern should be followed.

PRGRAMME OUTCOME (POs)

- The aim of this course is to provide conceptual understanding, development of experimental skills, designing and implementation of novel synthetic methods, developing the aptitude for academic and professional skills, acquiring the basic concepts for structural elucidation with hyphenated techniques, understanding the fundamental chemical and biological processes and rationale towards computer.
- This curriculum would allow students to develop a strong footing in the fundamentals and to specialize in the disciplines of his/her liking and abilities.
- Students will be able to select research domain and present a synopsis of work.
- Students will be able to assess the impact of chemicals on the society as a whole and will be able to create awareness and development for the general community.
- To provide students broad theoretical and applied background in all specialization of chemistry with emphasis on qualitative and quantitative technique.
- To provide broad knowledge of interdisciplinary branches of chemistry involving applied inorganic, organic, physical, nano-technology and biochemistry.

PROGRAMME SPECIFIC OUTCOME (PSOs)

At the completion of the M.Sc. Chemistry program, the students of our Department will be able to**:**

- PSO1: Clear understanding of the fundamental concepts of organic, Inorganic, analytical and physical chemistry.
- PSO2: Opportunity and experiences of presenting seminar, project writing skill on pre-allotted topics related to theory.
- PSO3: Understanding on advanced topics of chemistry - quantum chemistry, group theory, reaction dynamics, statistical thermodynamics, bio-electrodics and fuel cell technology.
- PSO4: Analyse experimental data, and interpret results. They know the proper procedures and regulations for safe handling and use of chemicals and can follow the proper procedures and regulations for safe handling when using chemicals.

- PSO5: Acquire basic understanding of molecular spectroscopy and skill to solve problem based on NMR, ESR, IR.
- PSO6: Apply quantum mechanical approach to calculate energy of chemical system.
- PSO7: Acquire knowledge of important laboratory techniques, method and instrumentation.
- PSO8: To provide hands on experience on general chemical testing procedure.
- PSO9: Understand the chemistry of bioinorganic and bioorganic products.
- PSO10: To provide the students experience about the synthesis of industrially significant chemical.
- PSO11: The aim of introducing assignment ability work is to enable deep thinking of underlying concepts, exposure and the real world skill set on working and handling of scientific equipment.
- PSO12: Aware advanced techniques and ideas required in developing area of Chemistry.
- PSO13: Make aware and handle the sophisticated instruments/equipment.
- PSO14: To provide the laboratory experience to the students by performing lab experiments based on - qualitative and quantitative analysis, synthesis, characterization, separation and identification of organic and inorganic compounds.
- PSO15: To acquire knowledge about electroanalytical technique by performing laboratory experiment.
- PSO16: The project/Dissertation introduced in the curriculum will motivate the students to pursue the research and find a job in reputed pharmaceutical and other industries in India and abroad.

PROGRAMME ATTRIBUTES

- ❖ Disciplinary Knowledge
- ❖ Communication skills
- ❖ Critical thinking
- ❖ Problem solving
- ❖ Analytical reasoning
- ❖ Research related skills
- ❖ Cooperation/Team work
- ❖ Scientific reasoning
- ❖ Reflective thinking
- ❖ Information/digital literacy
- ❖ Self-directed learning
- ❖ Moral and ethical awareness
- ❖ Leadership qualities

SCHEME OF EXAMINATIONS

1. The evaluation scheme of examination consists of two parts: Internal Assessment (IA), Mid Semester Exam (MSE) and End Semester Examination (ESE). Internal assessment includes Assignments, Presentations, Seminars, Quizzes, Case studies, Viva, Unit test, Group activities /Discussion, etc. The internal assessment will contribute 40% and the Semester and examination will contribute 60% to the total marks. This shall apply to both types of examination system i.e., Semester- wise and Choice based credit system (CBCS) based examination.

**Note: The ratio of internal assessment and semester and examination will be the same as determined by the University.

2. There shall be continuous assessment of the student in each course. The course instructor shall hold a maximum of three and minimum of one internal test/assignment /presentation, etc. The distribution of marks in internal assessment will be in two parts; 20% (Mid Sem. Exam) and 20% (Assignments/Presentations/Group Discussion etc.
3. In case of semester examination, there shall be no binding on the number of external paper setters/examiners, though in case of CBCS//CBSS system, generally the course instructor shall be the paper setter and examiner. However, the Core courses comprising "Dissertation and Viva-Voce — and "Project Work and Viva-Voce‖ respectively will be evaluated / examined by Board/s consisting of one external examiner and one internal examiner who shall be the Chairman of the Board. The Dissertation / Project Work and Viva-Voce shall equal weightage and would be judged separately. The remuneration for these courses would be at par with such courses been run in other Department of the University.
4. The duration of the End Semester Examination (ESE) of each course will be 3/2 Hours.
5. English shall be the medium of the instruction and examination.
6. Examination shall be conducted at end of each semester as per the academic calendar notified by the Nehru Gram Bharti (Deemed to be University).The system of evaluation shall be as follows:
    a. Each course will carry 25 marks for every credit, of which 40% shall be reserved for internal assessment based on classroom participation, seminar, term courses, testes and attendance. The weightage given to each of these components shall be decided and announced at the beginning of the semester by the individual teacher responsible for the course. Any student who fails to participate in classes, seminars, term courses, tests, will have to face disciplinary action decided by the university.
    b. The remaining 60% marks in each paper shall be awarded on the basis of a written examination at the end of each semester. The duration of written examination for each paper shall be three hours and the practical examination shall be of six hours. The paper of written examination shall be divided in to two sections and a candidate has to answer 5 questions of equal marks.
    c. A candidate is allowed to reappear ONLY in THEORY papers to improve his/her previous performance.
    d. Examinations for courses shall be conducted only in the respective odd and even semesters as per the Scheme of Examinations. Regular as well as Ex-Students shall be permitted to appear/re-appear/improve in courses of Odd Semesters only at the end of Odd Semesters and courses of Even Semesters only at the end of Even Semester

TEACHING – LEARNING PROCESS

M.Sc. Chemistry programme is a two-year degree programme designed to provide students with a sound theoretical background and practical training in all aspects of chemistry. The programme includes foundational as well as in-depth courses of chemistry. These courses are delivered through classroom, laboratory work, projects, case studies and fieldwork in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and tools (PowerPoint presentations, audio visual resources, e-resources, seminars, workshops, models, softwares). The laboratory training complements the theoretical principles learned in the classroom and includes synthesis of molecules, measurement of chemical properties and phenomenon, hands-on

experience and laboratory safety procedures. These promote independent thinking, critical thinking, reasoning, and a perspective of chemistry as a scientific process of discovery. Students are encouraged to work together in groups that leads to development of interpersonal skills like communication and teamwork. The student will participate in industrial visits that will lay strong foundation for a successful career as a professional chemist by providing him/her useful information related to the practical aspects of the course and giving an insight to future areas of employment.

COURSE CONTENT
M.Sc. (CHEMISTRY)
CORE PAPERS
Semester I
Paper - I
Inorganic Chemistry - I (CHE-101)
Total Lectures– 54 Credits: 3

Course Objective- To impart advanced knowledge of atomic structure based on quantum mechanics, concept of VBT & MOT, term symbols, Frank codon principles and theories of transition metal complexes.

Course Outcome- At the end of course student is expected to understand

- Bohr‘s theory, de Broglie equation, Heisenberg‘s Uncertainty Principle, Schrödinger‘s wave equation.
- Concept of MO and VB theory, resonance, molecular dipole moment, polarizing power and polarizability, Fajan‘s rules.
- Inorganic Spectroscopy, Microstates and term symbols.
- Principles of Electronic Spectroscopy-Franck-Condon principle.
- Introduction to transition metal complexes

Unit I **Lectures: 12**

Review of Bohr‘s theory, its limitations and the atomic spectrum of hydrogen atoms. Wave mechanics: de Broglie equation, Heisenberg‘s Uncertainty Principle and its significance. Schrödinger‘s wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Radial and angular wave functions for hydrogen atoms. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli‘s Exclusion Principle, Hund‘s rule of maximum multiplicity, aufbau principle and its limitations.

Unit II **Lectures: 10**

Bonding and structure: Types of bonds, orbital symmetry and overlaps, concept of MO and VB theory, concept of hybridization, bond energy and covalent radii, concept of resonance, molecular dipole moment, polarizing power and polarizability, Fajan‘s rules.

Unit III **Lectures: 11**

Inorganic Spectroscopy I- Number of microstates and term symbols for gaseous free

atoms and ions. Hund's rules. Splitting of spectroscopic terms of $p^2$and d^2 configurations.

Unit IV **Lectures: 11**

Inorganic Spectroscopy II- Principles of Electronic Spectroscopy-Franck-Condon principle, selection rules, Different types of electronic transitions and molar absorption coefficient.

Unit V **Lectures: 10**

Introduction to transition metal complexes- Brief review of the general characteristics of transition elements, types of ligands, Nomenclature of coordination complexes, chelates, chelate effect, Werner, Sidgwick and VSEPR theory.

Teaching Learning Process

- White board and marker teaching.
- Learning through quiz design.
- Class interactions and discussions
- Problem solving to enhance comprehension.

Assessment Methods

- In text question,
- Poster presentation/Oral test/seminar
- Class tests at periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *Principles of Inorganic Chemistry, B.R.Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers and Distributors/ Vishal Publishing Co.*
2. *Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley. Concise Inorganic Chemistry, J.D. Lee,Wiley.*
3. *Inorganic Chemistry, J.E. Huhey, Harper & Row.*
4. *Chemistry of the Elements. N.N. Greenwood, A. Earnshow, Pergamon. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.*
5. *Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. Mc Cleverty, Pergamon.*

Paper - II
Organic Chemistry - I (CHE-102)
Total Lectures – 54 Credits: 3

Course Objective- To impart knowledge of stereochemistry, aromaticity, reactive intermediates, aliphatic nucleophilic substitution & electrophilic substitution.

Course Outcome- At the end of course student will be able to:

- Understand the fundamental concepts of stereochemistryin acyclic and cyclic compounds.
- Learn and identify Benzenoid and non-benzenoid compounds.
- Understand about the reactive intermediates generates in organic reactions.
- Learn and identify organic reaction including Aliphatic Nueleophilic Substitution
- Learn and identify organic reaction including Aliphatic Electrophilic Substitution

Unit I **Lectures: 10**

Principles of stereochemistry- Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.

Unit II **Lectures: 10**

Aromaticity- Benzenoid and non-benzenoid compounds – generation and reactions.

Unit III **Lectures: 8**

Organic reactive intermediates- Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.

Unit IV **Lectures: 14**

Aliphatic Nueleophilic Substitution- The S_N2, S_N1, mixed S_N1 and S_N2 and SET mechanisms. The neighboring group mechanism, neighboring group participation by p and s bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangement. The S_Ni mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis, ambident nucleophile and regioselectivity.

Unit V **Lectures: 12**

Aliphatic Electrophilic Substitution- Bimolecular mechanisms, - S_E2 and S_E1. The S_E1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

Teaching Learning Process

- Lecture in classrooms.
- Learning through quiz design.
- Class interactions and discussions
- Problem solving to enhance comprehension.

Assessment Methods

Assessment will be done based on regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Advanced Organic Chemistry, Jagdamba Singh, Pragati Prakashan.*
2. *Organic Chemistry: Concepts and Applications, Jagdamba Singh, Pragati Prakashan.*
3. *Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.*
4. *Advanced Organic Chemistry Part A: Structure and Mechanisms, Francis A. Carey,Richard J.Sundberg, Springer.*
5. *A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.*
6. *Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.*
7. *Organic Chemistry, R.T. Morrison, R.N. Boyd, Prentice-Hall.*
8. *Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan.*
9. *Stereochemistry of Organic Compounds, D.Nasipuri, New Age International.*
10. *Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.*

Paper - III
Physical Chemistry - I (CHE-103)
Total Lectures – 54 Credits: 3

Course Objective- Aim to Revise and update thermodynamics concepts. Provide knowledge of mathematics for chemist, concept of operators, surface-active agents and surface chemistry.

Course Outcome- At the end of course student is expected to understand:

- ❖ Concepts of laws of thermodynamics.
- ❖ Mathematical chemistry -Probability, Matrices, Determinants, Series, Stirling approximation.
- ❖ Concept of operators in quantum mechanics.
- ❖ Surface active agents.
- ❖ Laplace law, Kelvin equation

Unit I **Lectures: 12**

Brief resume of concepts of laws of thermodynamics, free energy, chemical

potential, partial molar free energy, partial molar volume and partial molar heat content and their significance. Determinations of these quantities. Concept of fugacity and determination of fugacity.

Unit II **Lectures: 12**

Linear graphs and slopes, curve sketching, polynomial, exponential function, differentiation formulas, chain rule, maxima and minima, partial and total differential, exact and inexact differential. Integration formulas, permutations and combinations, probability, matrices, determinants, series, Stirling approximation, Euler reciprocal relation.

Unit III **Lectures: 12**

Concept of operators in quantum mechanics- operators for velocity, kinetic energy, momentum and angular momentum. Laplacian and Hamiltonian operator, Schrödinger‘s equation and its solution for hydrogen atoms. Derivation of Heisenberg‘s uncertainty principle.

Unit IV **Lectures: 10**

Surface- active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation and mass action models, reverse micelles, Micro emulsion.

Unit V **Lectures: 8**

Surface tension, capillary action, Laplace law, Kelvin equation (vapour pressure of droplets), BET equation of estimation of surface area.

Teaching Learning Process

- White board and marker teaching.
- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Learning through quiz design.
- Class interactions and discussions
- Problem solving to enhance comprehension.
- Revising and asking questions at the end of class.
- Correlating topic with real life cases.

Assessment Methods

- In text question,
- Poster presentation/Oral test/seminar
- Class tests at periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Modern Electrochemistry, Vol. 1, Vol. 2A and Vol. 2 B, J.O'M. Bockris, A.K.N. Reddy,Plenum Press, New York.*
2. *Electrochemical Methods: Fundamentals and Applications, A.J. Bard, L.R. Faulkner, John Wiley and Sons, New York.*
3. *Physical Chemistry, P.W. Atkins, ELBS.*
4. *Physical Chemistry, Levine.*
5. *Thermodynamics, Gurdeep Raj.*
6. *Physical Chemistry, G. W.Castellan.*

Chemistry Laboratory (CHE-L1)
Credits: 3

Course Objective- The course is aimed at introducing students to General Chemistry Laboratory safety measures and exposure them to the basic laboratory operations. Experiments are designed in such a way so that students can enjoy learning some of the basic chemistry exercises.

Course Outcome- At the end of course student is expected to understand:

- ❖ Familiar with the safe working practices in chemistry laboratory.
- ❖ Able to handle the apparatus, chemicals and equipment safely.
- ❖ Familiar with basic laboratory apparatus/equipments like burette, pipettes, conical flask, weighing bottle etc.
- ❖ Able to understand working protocols related to various methods pH metric, kinetics study qualitative and quantitative determination, separation, estimation etc.

Inorganic Chemistry:

1. Qualitative analysis of inorganic mixture for seven radicals only (including interfering radicals, insolubles, and two rare elements.
2. Quantitative separation and estimation of individual metal component from binary mixture solution (either both component gravimetrically or one component gravimetrically and other one volumetrically).

Organic Chemistry:

Organic synthesis: (any two)

1. Oxidation: synthesis of Adipic acid by chromic acid oxidation.
2. Aldol condensation: synthesis of Dibenzalacetone from Benzaldehyde.
3. Rearrangement: Synthesis of Benzilic acid by Benzil - Benzilic acid rearrangement.

Physical Chemistry: (any two)

1. Potentiometric/pH metric titration.
2. Determine the concentration or percentage of one or two optically active substances in the given solution polarimetrically.
3. Kinetics of oxidation of reducing sugars by potassium ferricyanide in presence of ammonium hydroxide or sodium hydroxide.
4. Kinetics of oxidation of alcohols/diols by aqueous alkaline hexacyanoferrate (III) ions.
5. Conductometric titration.
6. Molecular weight determination using viscometry.

Teaching Learning Process

- Hands-on laboratory exercises.
- Conventional teaching learning method.
- Engaging students in collaborative learning.

Assessment Methods

- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Presentation on good lab practices.
- Performance in the experiment on the date of end semester university examination and viva voce.

Suggested reading: *Lab manual.*

ELECTIVE PAPERS - I

Paper - IV

Solvent Extraction and Chromatography (CHE-104)

Total Lectures – 54 Credits: 3

Course Objective- To impart fundamental knowledge about the principle and application of different types of chromatographic techniques of separation.

Course Outcome- At the end of course student is expected to understand

- Principles and applications of solvent extraction.
- Ion exchange Resins.
- Ion Chromatography and applications.
- Partition Chromatography and its applied aspects.
- Principles of Electrophoresis

Unit I **Lectures: 12**

Principles and applications of solvent extraction- quantitative treatments of extraction equilibria, solvent extraction of metals, analytical separation, multiple batch extraction, counter current distribution, synergistic extraction. Solid –phase extraction, Supramolecules in solvent extraction

Unit II **Lectures: 10**

Ion exchange Resins– Mechanism of ion exchange, synthesis and characteristics of ion-exchange resins, factors affecting the selectivity of ion exchange resin, ion exchange capacity, techniques in ion exchange methods and analytical applications.

Unit III **Lectures: 08**

Ion Chromatography– Ion chromatography as a separation tool, instrumentation in Ion chromatography; analytical applications of ion chromatography.
Adsorption chromatography– Principle, experimental Set up and use of Adsorption chromatography

Unit IV **Lectures: 12**

Partition Chromatography- Principle of Liquid – Liquid partition chromatography reversed phase partition chromatography, application of extraction chromatography, paper, Thin Layer and Ion-pair chromatography.

Unit V **Lectures: 12**

Electrophoresis– Principles of electrophoresis – classification of electrophoresis methods, techniques of electrophoresis and instrumentation, applications in inorganic chemistry, separation of biological products.

Teaching Learning Process

- White board and marker teaching.
- Learning through quiz design.
- Class interactions and discussions
- Revising and asking questions at the end of class.
- Correlating topic with real life cases.
- Problem solving to enhance comprehension.

Assessment Methods
Assessment will be done based on regular class test, Oral test/seminar/presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links

- Digital library links
- NGB e-library
- Departmental library

Books Recommended *(Names of Publishers may vary as per copyright status):*

1. *G.H. and H. Freiser, Solvent Extraction in Analytical Chemistry, 1st Edition (1958), John Wiley, New York.*
2. *B.L. Karger, L.R. Snyder and C. Howarth, An Introduction to Separation Science, 2nd Edition (1973), John Wiley, New York.*
3. *E.W. Berg, Chemical Methods of Separation, 1st Edition (1963), McGraw Hill, New York.*
4. *D.G. Peters, J.M. Hayes and C.M. Hieftj, Chemical Separation and Measurements, 2nd Edition (1974), Saunders Holt, London.*
5. *J.D. Seader and E.J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.*

Introduction to Analytical Chemistry I (CHE-105)

Total Lectures – 54 Credits: 3

Course Objective- To impart fundamental knowledge about the principle and application of various analytical techniques.

Course Outcome- At the end of course student is expected to understand:

- ❖ Methods of qualitative and quantitative analysis.
- ❖ Thermoanalytical technique.
- ❖ Electro Analytical Techniques
- ❖ Diffraction Techniques.
- ❖ Electrochemical Techniques

Unit I **Lectures: 7**

Methods involve in qualitative and quantitative analysis.

Unit II **Lectures: 13**

Thermal Analysis- Introduction, types and applications of thermoanalytical methods, thermogravimetry.

Unit III **Lectures: 14**

Electro Analytical Techniques- Voltametry, Amperometry, Coulometry, Conductometry, Potentiometry.

Unit IV **Lectures: 10**

Diffraction Techniques- Introduction, types and applications with special reference to x-ray diffraction technique.

Unit V **Lectures: 10**

Electrochemical Techniques- Introduction and applications of Electrolysis, Electrophoresis.

Teaching Learning Process

- ❖ Teaching Learning Process for the course is visualized as largely student-focused.
- ❖ Transaction through an intelligent mix of conventional and modern methods.
- ❖ Engaging students in cooperative learning.
- ❖ Learning through quiz design.
- ❖ Problem solving to enhance comprehension.
- ❖ White board and marker teaching

Assessment Methods

- In text question,
- Poster presentation/Oral test/seminar
- Class tests at periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested *(Names of Publishers may vary as per copyright status)*

1. *Analytical Chemistry, G.D. Christian, J.Wiley.*
2. *Fundamentals of analytical Chemistry, D.A. Skoog. D.M. West, F.J. Hooler, W.B. Saunders.*
3. *Analytical Chemistry-Principles, J.H. Kennedy, W.B. Saunders.*
4. *Analytical Chemistry-Principles and Techniques, LG. Hargis, Prentice Hall.*
5. *Principles of Instrumental analysis, D.A. Skoog, J.L. Loary, W.B. Saunders.*
6. *Principles of Instrumental Analysis, D.A. Skoog, W.B. Saunders.*
7. *Quantitative Analysis, R.A. Day, Jr., A.L. Underwood, Prentice Hall.*
8. *Basic Concepts of Analysis Chemistry, S.M. Khopkar, Wiley Eastern.*
9. *Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.*

Computer Application in Chemistry (CHE-106)
Total Lectures– 54 Credits: 3

Course Objective: The aim of this paper is to make the students learn the basic working of computer and its applications in chemistry via programming language, FORTRAN and use of software as a tool to understand chemistry, and solve chemistry based problems.

Course Outcome- At the end of course student is expected to understand:

- Basic structure and functioning of computers.
- Programming language and various types of I/O statements.
- Numerical methods.
- Computer programming based on FORTRAN or other language.
- Available standard application packages

Unit I **Lectures: 10**

Basic structure and functioning of computers with a PC as an illustrative example. Memory, I/O devices. Secondary storage. Computer languages. Operating systems with DOS as an example. Introduction to UNIX and WINDOWS. Data processing. Principle of programming. Algorithms and flow charts,

Unit II **Lectures: 14**

FORTRAN Programming- (The language features are listed here with reference to FORTRAN. The instructor may choose any other language currently available in place of FOTRAN and features may be replaced appropriately). Types of constants and variables, dimension, Data, Type, COMMON and EQUIVALENCE statements, arithmetic and logical IF, IF-THENELSE constructs, _DO' statement,
Various types of _I/O'statements, Library functions, Statement functions, Function subprograms and subroutine subprograms.

Unit III **Lectures: 10**

Numerical Methods- Roots of Polynomials, Solution of Linear simultaneous equations, matrix multiplication and inversion. Numerical integration. Statistical treatment of data, variance and correlations.

Unit IV **Lectures: 10**

Computer programming based on FORTRAN (or programming based on other language choosen by instructor) and Numerical methods

Unit V **Lectures: 10**

Exposure to available standard application packages like- Chemdraw, generation of graphs, data sheets creation, and tables using excel programme.

Teaching Learning Process

- ❖ Teaching Learning Process for the course is visualized as largely student-focused.
- ❖ Transaction through an intelligent mix of conventional and modern methods.
- ❖ Engaging students in cooperative learning.
- ❖ Learning through quiz design.
- ❖ Problem solving to enhance comprehension.
- ❖ White board and marker teaching

Assessment Methods

- Assigned project,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Recommended

1. *V. Rajaraman, Fortran 77, Prentice Hall (India), New Delhi (1997)*
2. *C. Xavier, Fortran 77 and Numerical Methods, New Age International Pvt. Ltd. Publishers, New Delhi (1994)*
3. *S. Lipschutz and A. Poe, Schaum's Outline Series– Theory and Problems of Programming with Fortran including structured Fortran, Mc Graw Hill Book Company, Singapore (1982)*
4. *K. V. Raman, Computers in Chemistry, Tata McGraw Hill (1993). [Reference book]*

SKILL DEVELOPMENT - I

Paper - V

Laboratory Techniques and Data Interpretation (CHE-107)

Total Lectures – 36 Credits: 2

Course Objective: The objective of this course is to make students aware about the importance and the concepts in chemical analysis and experimental data interpretation.

Course Outcome- At the end of course student is expected to understand:

- ❖ Methods of qualitative and Quantitative analysis.
- ❖ Calibration and handling of lab equipments /instruments.

- ❖ Solution preparation.
- ❖ Separation and identification techniques.
- ❖ Statistical analysis and interpretation of experimental data.

1. Methods involve in qualitative and Quantitative analysis.
2. Calibration and handling of lab equipments/instruments.
3. Preparation of solution.
4. Laboratory separation and identification techniques.
5. Statistical analysis and interpretation of data (qualitative/quantitative/ both).

Teaching Learning Process Lectures, presentations, learning through quiz design, discussions, demonstration, and problem solving will be part of teaching learning process.
Assessment Methods: Internal assessment will be through assignments, projects, presentation and class test. End semester examination will be for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested *(Names of Publishers may vary as per copyright status)*

1. *Analytical Chemistry, G.D. Christian, J.Wiley.*
2. *Fundamentals of analytical Chemistry, D.A. Skoog. D.M. West, F.J. Hooler, W.B. Saunders.*
3. *Analytical Chemistry-Principles, J.H. Kennedy, W.B. Saunders.*
4. *Analytical Chemistry-Principles and Techniques, LG. Hargis, Prentice Hall.*
5. *Quantitative Analysis, R.A. Day, Jr., A.L. Underwood, Prentice Hall.*
6. *Basic Concepts of Analysis Chemistry, S.M. Khopkar, Wiley Eastern.*
7. *Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.*

UNIVERSITY ELECTIVE – I

(Not for chemistry students)
Paper - VI
Polymer Chemistry (CHE-108)
Total Lectures – 54 Credits: 3

Course Objective: The objective of this course is to make students aware about the polymer, biopolymer, structure, separation and importance of polymer in various field.

Course Outcome- At the end of course student is expected to understand:

- ❖ Classification of polymers.
- ❖ Structure, Separation and Properties of Polyethylene, PVC.
- ❖ Polymer solutions.
- ❖ Biomedical and Engineering Application.
- ❖ Bio polymers DNA, RNA

1. Introduction: Definition and Classification of polymers.
2. Structure, Separation and Properties of Polyethylene, PVC
3. Polymer solutions: Nature, Size and Shapes of Macromolecules in solution.
4. Biomedical and Engineering Application: Tissue engineering, Controlled drug release.
5. Bio polymers DNA, RNA

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Activating prior knowledge by Random questioning.
- ❖ Real life example to lifelong learning,
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Recommended

1. *Text Book of Polymer Science, 3rd Edition (1984), F. W. Billmayer, Jr., Willey- Interscience, New York.*
2. *Physical Chemistry, 8th Edition, P. W. Atkins, Oxford University Press, New York. Year*
3. *Principles of Polymerization, 3rd Edition (1991) G. Odian, John Wiley, Singapore*
4. *Principle of Polymer Sciences, P. Bahadur and N.V. Sastry, Narosa Publishing House, New Delhi (2002).*
5. *Polymer Sciences, V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar , Wiley Eastern, New Delhi (1986).*

Semester II

Paper - I

Inorganic Chemistry - II (CHE-201)

Total Lectures – 54 Credits: 3

Course Objective: The objective of this course is to make students aware about crystal field theory, electronic spectra of transition metal complexes, bonding & structure in cobonyls & nitrosyls, the general chemistry of d-block elements and actinides.

Course Outcome- At the end of course student is expected to understand:

- Theories of the coordinate linkage.
- Electronic absorption spectra of transition metal complexes.
- Metal Carbonyls and Nitrosyls
- Chemistry of f-Block Elements.
- General chemistry of actinides including E.M.F. diagrams.

Unit I **Lectures: 10**

Theories of the coordinate linkage- Valence bond, crystal field, ligand field and molecular orbital theories. Crystal field splitting of d-orbitals in octahedral, tetrahedral, tetragonal and square planar complexes. Crystal field stabilization energy (CFSE). M.O. energy level diagram for octahedral and tetrahedral complexes (with s bonding only). Spectrochemical series.

Unit II **Lectures: 12**

Electronic absorption spectra of transition metal complexes. Orgel diagrams for d^1, d^4, d^6 and d^9 configurations with D ground state. Jahn-Teller effect.

Unit III **Lectures: 12**

Metal carbonyls and nitrosyls: Mononuclear and polynuclear carbonyls and their structures. Nature of M-C-O bonding. Preparation of metal carbonyls and their reactions. Metal nitrosyls-bonding and structure. Metal carbonyl-nitrosyl complexes.

Unit IV **Lectures: 10**

Chemistry of f-Block Elements- Comparative study of lanthanides and actinides with special reference to electronic structure. Oxidation state, coordination number, structure, stereochemistry and magnetic and spectral properties.

Unit V **Lectures: 10**

General chemistry of actinides including E.M.F. diagrams. Extraction and metallurgy of thorium and uranium. Technical production of plutonium.

Teaching Learning Process

- White board and marker teaching.
- Teaching Learning Process for the course is visualized as largely student-focused.

- ❖ Learning through quiz design.
- ❖ Class interactions and discussions
- ❖ Problem solving to enhance comprehension.
- ❖ Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test/seminar
- Class tests at periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *Advanced Inorganic Chemistry, F.A. Cotton, Wilkinson, John Wiley.*
2. *Inorganic Chemistry: Principles of Structure and Reactivity, Huheey, Medhi, Pearson Education India.*
3. *Physical Methods in Inorganic Chemistry, R S.Drago, Affiliated East-West Press Pvt. Ltd. Chemistry of the Elements. N.N. Greenwood, A. Earnshow, Pergamon.*
4. *Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.*
5. *Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillars, J.A.,Mc Cleverty,Pergamon.*

Paper - II
Organic Chemistry - II (CHE-202)
Total Lectures – 54 Credits: 3

Course Objective: The aim of this course is impart knowledge advanced topics of aromatic electrophilic & nucleophilic substitution reaction, mechanism of free radical, addition to carbon-carbon & elimination reaction.

Course Outcome- At the end of course student will be able to understand, identify and formulate:

- ❖ Aromatic Electrophilic Substitution.
- ❖ Aromatic Nucleophilic Substitution.
- ❖ Free Radical Reactions.
- ❖ Addition to Carbon-Hetero Multiple Bonds.
- ❖ Elimination Reactions.

Unit I **Lectures: 10**

Aromatic Electrophilic Substitution- The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack. Diazonium coupling Vilsmeier reaction, Gatterman-Koch reaction.

Unit II **Lectures: 10**

Aromatic Nucleophilic Substitution- The S_NAr, S_N1 benzyne and $S_{RN}1$ mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser and Smiles rearrangements.

Unit III **Lectures: 12**

Free Radical Reactions- Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighboring group assistance, reactivity for aliphatic and aromatic substrates at a bridgehead, Reactivity in the attacking radicals. The effect of solvent on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto oxidation, coupling of alkynes and arylation on aromatic compounds by diazonium salts. Sandmeyer reation. Free radical rearrangement. Hunsdiecker reaction.

Unit IV **Lectures: 13**

Addition to Carbon-Hetetero Multiple Bonds- Mechanism of metal hydride reduction of saturated and unasaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, Witting reaction.
Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

Unit V **Lectures: 9**

Elimination Reactions- The $E2$, $E1$ and $E1CB$ mechanisms, orientation of the double bond. Reactivity-effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

Teaching Learning Process:

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Class interactions and discussions
- Problem solving to enhance comprehension.
- Revising and asking questions at the end of class.

Assessment Methods:

- In text question,

- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material:

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Advanced Organic Chemistry, Jagdamba Singh, Pragati Prakashan.*
2. *Organic Chemistry: Concepts and Applications, Jagdamba Singh, Pragati Prakashan.*
3. *Advanced Organic Chemistry Part A: Structure and Mechanisms, Francis A. Carey, Richard J.Sundberg, Springer.*
4. *A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.*
5. *Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.*
6. *Organic Chemistry, R.T. Morrison, R.N. Boyd, Prentice-Hall.*
7. *Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan.*

Paper - III
Physical Chemistry - II (CHE-203)
Total Lectures – 54 Credits: 3

Course Objective- This course will help students to evaluate most probable distribution state for all type of statics i.e. for Maxwell-Boltzmann, Fermi -dirac and Bose –Einstein statistics, partition function, Debye's theory of solids, calorimetric and spectroscopic entropy and equilibrium constants in terms of partition function.

Course Outcome- At the end of course student is expected to understand and solve problems based on:

- ❖ Quantum mechanical approach of thermodynamics.
- ❖ Indistinguishability, thermodynamic functions.
- ❖ The Einstein model, and Debye's theory.
- ❖ Equilibrium constant in terms of partition functions.
- ❖ Types of statistics.

Unit I **Lectures: 10**

Quantum states and complexions, combinatory rule, System with definite total energy. Degeneracy of energy levels Probability and most probable distribution. Indistinguishability. Maxwell-Boltzmann statistics, partition function- Translational,

rotational, vibrational and electronic partition functions. Internal energy and heat capacity in terms of partition function.

Unit II **Lectures: 8**

Indistinguishability of gas molecules. Maxwell-Boltzmann law for gaseous system. Thermodynamic functions for gaseous systems. Molar heat capacity of gases. Heat capacity of hydrogen at low temperatures. Heat capacities of monatomic crystals.

Unit III **Lectures: 10**

The Einstein model, Debye's theory of solid. Heat capacities of crystals at very low temperatures. Calorimetric entropy. Spectroscopic entropy, Comparison of calorimetric and spectroscopic entropies

Unit IV **Lectures: 12**

Expression for equilibrium constant in terms of partition functions. Equilibrium constants of simple systems - (i) Ionization of metal atoms, (ii) Dissociation of diatomic molecules and (iii) Isotopic exchange equilibria.

Unit V **Lectures: 14**

Bose-Einstein statistics, Fermi-Dirac Statistics, Comparison of M-B, B-E and F-D statistics. Fermi-Dirac gas (electron gas in metals), Bose-Einstein gas (liquid Helium).

Teaching Learning Process Lectures, presentations, learning through quiz design, discussions, demonstration, problem solving and revising & asking questions at the end of class will be part of teaching learning process.

Assessment Methods

- In text question,
- Poster presentation/Oral test/seminar
- Class tests at periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library
- Departmental library

Books Suggested *(Names of Publishers may vary as per copyright status)*

1. *Physical Chemistry, P.W. Atkins, ELBS.*
2. *Physical Chemistry, Levine*
3. *Physical Chemistry, G. W.Castellan.*
4. *Statistical Mechanics, B.K. Agarwal, M. Eisner, Wiley Eastern, New Delhi.*
5. *Statistical Mechanics, R.K. Pathria, Butterworth-Heinemann.*
6. *Statistical Mechanics, D.A. Mcquarrie, California University Science Books.*

Chemistry Laboratory (CHE-L2)
Credits: 3

Course Objective- The course is aimed at introducing students to preparation and characterization of Coordination complexes, chemical method for separation & identification of organic mixtures, extraction of organic compounds from natural sources, study of velocity constant of some reaction, verification of Freundilich's adsorption isotherm etc.

Course Outcome- At the end of course student is expected to understand:

- Familiar with the safe working practices in chemistry laboratory.
- Able to handle the apparatus, chemicals and equipment safely.
- Familiar with preparation of coordination complexes and their characterizations.
- Able to understand working protocols related to various methods of extraction, separation and pH metric, kinetics study of reactions.

Inorganic Chemistry:

Preparation of Coordination complexes and their characterization by m.p. elemental analysis and molar conductivity measurements (Any two)

1. $VO(acac)_2$
2. $K_3[Cr(C_2O_4)_3].\ 3H_2O$
3. $Na[Cr(NH3)2\ (SCN)_4]$
4. $Mn(acac)_3$
5. $K_3[Fe(C_2O_4)_3]$
6. $Hg[Co(SCN)_4]$
7. $[Co(Py)_2Cl_2]$
8. $[Ni(NH)_6]Cl_2$

Study of recorded UV-visible and IR of above prepared coordination compounds.

Organic Chemistry:

1. Separation and identification of organic compounds using chemical methods from the organic mixtures containing up to three components.
2. Extraction of organic compounds from natural sources.
    a) Caseine from milk
    b) Lactose from milk

c) Nicotine from tobacco
d) B-carotene from carrot
e) Caffeine from tea leaves
f) Eugenol from cloves.

Physical Chemistry: (Any two exercise)

1. Determination of the velocity constant of the reaction between acetone and iodine catalysed by HCI/H_2SO4.
2. Determination of velocity constant of saponification of ethyl acetate with sodium hydroxide.
3. Kinetics of reaction between copper sulphate and sugars in alkaline medium.
4. Titration of acid versus base using pH meter and calculation of pKa value of an acid.
5. Elevation of boiling point using Landberger's apparatus.
6. To study the adsorption of oxalic acid on activated charcoal and test the validity of Freundilich's adsorption isotherm.
7. Rast method for determining molar mass.
8. Determination of the temperature dependence of E.M.F. using potentiometry/pH metry.
9. Determination of the solubility product.

Teaching Learning Process

- Hands-on laboratory exercises.
- Conventional teaching learning method.
- Engaging students in collaborative learning.

Assessment Methods

- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Presentation on good lab practices.
- Se
- m University examination

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s ***Suggested reading***: *Lab manual*
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ELECTIVE PAPERS - II

Papers - IV
Forensic Analysis (CHE-204)
Total Lectures – 54 Credits: 3

Course Outcome- The aim of the course is to introduce the students to forensic laboratory role and operations, real case analysis, forensic toxicology and instrumentation.

Course Outcome- At the end of course student is expected to understand:

- Forensic laboratory – role and operations.
- Real Case Analysis – liquor, petroleum and firearm analysis.
- Forensic Toxicology.
- Instrumentation for Forensic Analysis
- Instrumental Methods and SOPs

Unit I **Lectures: 8**

Introduction- Profile of a forensic laboratory, Forensic Scientists'role and quality control, Crime-scene investigation, Collection and preserving physical evidences and evidentiary documentation, Future prospects of forensic analysis

Unit II **Lectures: 8**

Real Case Analysis- Liquor analysis, Trap-case analysis, Petroleum product analysis, Fire and Debris analysis, Injuries, Firearm wounds, Asphyxia and stress analysis (only analytical identifications).

Unit III **Lectures: 14**

Forensic Toxicology- Analysis of various types of poisons (corrosive, irritant, analgesic, hypnotic, tranquillizer, narcotic, stimulants, paralytic, anti-histamine, domestic and industrial(gaseous and volatile) poisoning and food poisonings, explosive and explosion residue analysis, Lethal drug analysis(sampling, sealing, packing, laboratory methods of testing, reporting the analysis results, court evidence and medico-legal aspects for the consideration of chemical data as a proof for crime), Importance of physiological tests in forensic toxicology

Unit IV **Lectures: 14**

Instrumentation for Forensic Analysis- Physical, Biological and Chemical Methods: Non- destructive testing probes including radiography, Xera-radiography, Surface penetrations method (SEM and Laser Probes), Fluoroscopy, Clinical methods: ELISA, RIA and immunodiffusion , analysis of glucose, bilirubins, total cholesterol, creatinine, blood urea nitrogen and barbiturates in biological fluids, DNA-finger printing, Examination and grouping of blood strains and seminal strains, Data retrieval and automation techniques for forensic examination with reference to presence of drugs, glasses, paints, oils and adhesives at crime spot.

Unit IV **Lectures: 10**

Instrumental Methods: Sample preparation, calibration of instruments for accuracy and reproducibility of results in forensic analysis, method validation technique and requirements, procurement of standard samples, Forensic applications of TLC, HPTLC, HPLC, GC, FT-IR, AAS, GC-MS, UV-visible spectrophotometer with emphasis over standard operational procedures (SOPs) for test samples.

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Activating prior knowledge by Random questioning.
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.
- ❖ Correlating topic with real life examples.
- ❖ Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *W.J. Welcher (Ed.), Scott's Standard Methods of Chemical Analysis, Vol. III A, 6th Edition (1966), and vol. III B, 5th Edition (1975), Van Nostrand Reinhold Co. London.*
2. *Peter Fordham, Non-destructive Testing Techniques, 1st edition (1968), London Business Publications Ltd., London*
3. *W. Horwitz, Official Methods of Analysis, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.*
4. *K. Simpson and B. Knight, Forensic Medicine, 9th Edition (1985), Edward Arnold Publishers Ltd., London.*

Catalysis and Green Chemistry (CHE-205)
Total Lectures – 54 Credits: 3

Course Objective- To make students aware about green methodology in chemistry and its application.

Course Outcome- At the end of course student is expected to understand:

- ❖ Basic Principles of Green Chemistry.
- ❖ Green Reagent.
- ❖ Introduction and Basic concept of green catalysis.

- ❖ Green Catalyst.
- ❖ Aqueous Phase Reactions.

Unit I **Lectures: 10**

Basic Principles of Green Chemistry- Prevention of waste by products, maximum incorporation of the reactants into the final product, prevention or minimization of hazardous products, designing safer chemicals, energy requirements for synthesis, selection of appropriate solvent, selection of starting materials, use of protecting groups.

Unit II **Lectures: 8**

Green Reagent- Dimethylcarbonate, polymer supported reagent, polymer supported peracids, Poly-N-bromosuccinimide (PNBS), sulfonazide polymer, polystyrene Wittig reagent and polymer supported peptide coupling agent, miscellaneous reagents.

Unit III **Lectures: 10**

Introduction and Basic concept of green catalysis, Application of catalyst functionality, concepts for control of reaction, selectivity and kinetic models. Steps in catalytic reaction (Adsorption and Kinetic models). Selection and design and Preparation of catalysts.

Unit IV **Lectures: 12**

Green Catalyst- Acid catalyst, oxidation catalyst, basic catalyst, polymer supported catalyst, polystyrene– aluminium chloride, polymer supported photosensitizers, miscellaneous illustration and solid support reagents.

Unit V **Lectures: 14**

Aqueous Phase Reactions- Diels-Alder reaction, Claisen rearrangement, Wittig-Horner reaction, Michael reaction, Aldol condensation, Knoevenagel reaction, Pinacol coupling, Benzoin condensation, Claisen- Schmidt condensation. Strecker synthesis, Wurtz reaction, Oxidations, Reductions, Polymerization reactions, photochemical reactions, electrochemical synthesis & miscellaneous reactions in Aqueous Phase.

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.
- ❖ Problem solving to enhance comprehension.
- ❖ Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *New Trends in Green Chemistry,V.K. Ahluwalia, M.Kidwai, Anamaya publishers, New Delhi.*
2. *Introduction to Green Chemistry, V.Kumar.*
3. *Green Chemistry: Theory and Practice, Paul T. Anasta, John C. Warner, Oxford University Press.*
4. *Catalysis: Concepts and Green Applications, Gadi Rothenberg, Wiley.*

Introduction to Analytical Chemistry II (CHE-206)
Total Lectures – 54 Credits: 3

Course Objective- The objective of this course is to make student aware of the concept of error analysis, Accuracy, Precision, Statistical test data-F, Q, t test, titrimetric analysis, basic concept of spectrophotometric and separation techniques .

Course Outcome- At the end of course student is expected to understand:

- Errors analysis.
- Use of tests of significance – t, f , and q.
- Titrimetric analysis.
- Spectrophotometric methods.
- Separation Techniques

Unit I **Lectures: 8**

Errors analysis- Accuracy and precision, absolute, relative, determinate and indeterminate errors, statistical treatment of random errors, computation rules for significant figures, method of least squares, mean deviations, and standard deviation.

Unit II **Lectures: 8**

Tests of significance, the‘t’ test, the ‘F’ test, the χ^2 (chi-squares) test, distribution normalcy test. Regression analysis; methods of least squares the correlation coefficient, rejection of observations; the ‘Q’ test.

Unit III **Lectures: 9**

Titrations- Acid-base, complexometric, conductometric and potentiometric titration-theory of acid base indicators, Mohr, Volhard and Fajan’s methods, EDTA based titration, Redox indicators, and their use in volumetric analysis.

Unit IV **Lectures: 11**

Methodology and instrumentation of spectrophotometry in visible, ultraviolet and infra-red regions, spectrometric error, deviation from Beer's law, analysis of mixtures. Spectrophotometric methods for investigations of composition and stability of metal complexes in solutions.

Unit V **Lectures: 18**

Separation Techniques- Solvent extraction, thin-layer chromatography, gas chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC), ion exchange chromatography, gel permeation chromatography. Chromatography coupled instrumentation.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Class interactions and discussions
- Power point presentation on important topics.
- Problem solving to enhance comprehension.
- Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Analytical Chemistry, G.D. Christian, J.Wiley.*
2. *Fundamentals of analytical Chemistry, D.A. Skoog. D.M. West, F.J. Hooler, W.B. Saunders.*
3. *Principles of Instrumental analysis, D.A. Skoog, J.L. Loary, W.B. Saunders.*
4. *Principles of Instrumental Analysis, D.A. Skoog, W.B. Saunders.*
5. *Quantitative Analysis, R.A. Day, Jr., A.L. Underwood, Prentice Hall.*
6. *Environmental Solution, S.M. Khopkar, Wiley Eastern.*
7. *Basic Concepts of Analysis Chemistry, S.M. Khopkar, Wiley Eastern.*

8. *Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.*

SKILL DEVELOPMENT - II

Paper - V

Analysis and determination Lab (CHE-207)

Credits: 2

Course Objective- To provide student along with teaching hands on experience of various industrial analysis.

Course Outcome- At the end of course student is expected to understand:

- ❖ Analysis of dairy products and petrochemicals.
- ❖ Determination of physico-chemical parameters of waters/ given sample
- ❖ Food analysis
- ❖ Methods of removal of waste and hazardous metal from water

1. Analysis of dairy products and petrochemicals.
2. Determination of physico-chemical parameters of waters/ given sample.
3. Food analysis
4. Methods of removal of waste and hazardous metal from water.

Teaching Learning Process

- ❖ This course has major components of hands on exercises. The teaching learning process will require white board and marker teaching along with hands on exercise in Laboratory.

Assessment Methods

- Assessment on solving chemistry experiment related problems.
- Presentation on documentation preparation on any chemistry topic involving data tables and graphs.
- Semester end practical and theory examination.
- In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Essential Learning Material

- Text Books
- Video links
- Digital library links
- NGB e-library

Books Recommended

1. *D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Harcourt Brace & Company, Florida.*
2. *R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of*

Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
3. *J.M. Hollas, Modern Spectroscopy, 3rd Edition (1996), John Wiley, New York.*
4. *H.A. Strobel, Chemical Instrumentation – A Systematic Approach, 2nd Edition (1973), Addison Wesley, Mass.*
5. *D.C. Garratt, the Quantitative Analysis of Drugs, 2nd Edition (1992), Chapman and Hall Ltd., London.*
6. *W. Horwitz (Editor), Official Methods of Analysis, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC*

UNIVERSITY ELECTIVE – I

(Not for Chemistry students)
Paper- VI
Organic Chemistry (Applied Aspects Only) (CHE-208)
Total Lectures – 54 Credits: 3

Course Objective- To provide knowledge about applied aspects of organic chemistry.

Course Outcome- At the end of course student is expected to understand:

- Organic chemistry and industry
- Brief introduction of drugs
- Overview of antiviral drugs
- Bio-polymers
- Synthetic polymers

1. Organic chemistry and industry
2. Brief introduction of the molecules Aspirin, adrenaline, coniine, thujone, cholesterol, prostaglandins, penicillines.
3. Overview of antiviral drugs.
4. Bio-polymers: Polysaccharides - starch, cellulose, sucrose amino acids- polypeptides, proteins.
5. Synthetic polymers: properties and uses - Polyester, poly-tetrafluoroethylene, polyamino acids, polycyanoacrylates, polyurethanes, silicone rubbers, polymeric antioxidants.

Teaching Learning Process

- White board and marker teaching
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Recommended

1. *Yescombe, Sources of information on rubber, plastic and allied industries, Pergamon Press, 1968.*
2. *Peter Bernfeld,Biogenesis of Natural compounds,2nd edition, Pergamon press,1967.*
3. *J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic chemistry, Oxford University press INC, New York, 2001*
4. *Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry,3rd edition, Pearson Prentice Hall,200.*

SPECIALIZATION PAPERS
SEMESTER III
Inorganic Chemistry
Paper - I
Bioinorganic Chemistry -S- l (CHE-301l)

Course Objective- The course introduces some important topics of inorganic chemistry in a compact way. This course introduces students to the basic concepts of metal complexes of biological significance and its role in biological system.

Course Outcome- At the end of course student is expected to understand

- ❖ Complexes of Biological Significance
- ❖ Synthetic model oxygen carrier complexes
- ❖ Role of Metal Ions in Biological Systems
- ❖ Metalloproteins and Metalloenzymes
- ❖ Electron Transport Proteins

Unit I **Lectures:10**

Complexes of Biological Significance- Metal complexes of amino acids and peptides. Metal complexes of nucleic acid bases, nucleosides and nucleotides. Metal complexes of porphyrins and phthalocyanines.

Unit II **Lectures:10**

Synthetic model oxygen carrier complexes and model dinitrogen complexes. Phosphates and bioenergetics. Phosphorylation and phosphorolysis. Adenine nucleotides in metabolic energy transfer. Oxidation of glucose and the role of phosphate.

Unit III **Lectures:16**

Role of Metal Ions in Biological Systems- Essential and trace metal ions. Metal ions storage and transport (Na, K, Ca, Mg, Fe, Cu and Zn)-Ferritin and Transferrin. Metal ion toxicity and its cure by chelating agents. Pharmacological activity and metal chelates. Carcinogenic metals Carcinogenic and carcinostatic ligands.

Unit IV **Lectures:08**

MetalloProteins and MetalloEnzymes- Function, electronic structure, bonding and stereochemistry of the active site. Natural Oxygen Carrying Proteins-Haemoglobin, Myoglobin, Hemerythrin and Hemocyanin,

Unit V **Lectures:10**

Electron Transport Proteins (a) Iron-Sulfur Proteins-Rubredoxin and Ferredoxins, (b) Cytochromes (types a, b and c).

Teaching Learning Process:

- ❖ White board and marker teaching
- ❖ Learning through quiz design.
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods:

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide,llW. Kaim, B. Schwederski, Wiley, New York.*
2. *Inorganic Chemistry of Biological Processes, M. N. Hughes , John-Wiley and Sons, New York.*
3. *Principles of Bioinorganic Chemistry, S. J. Lippard, J. M. Berg, University Science Books.*
4. *Bioinorganic Chemistry, I. Bertini, H. B. Grey, S. J. Lippard, J. S. Valentine, Viva Books Pvt. Ltd., New Delhi.*

Inorganic Chemistry
Paper - II
Organometallic Chemistry of Transition Metals-S- ll (CHE-302I)
Total Lectures – 54 Credits: 3

Course Objective: Aim of this course to introduce students some important topics of organometallic chemistry of transition metals.

Course Outcome- At the end of course student is expected to understand:

- Inorganic π Acid Ligands
- π complexes of unsaturated molecules
- Transition organometallic compounds
- Transition metal compounds in catalysis
- Transition metal Compounds with M-H bonds

Unit I **Lectures:10**

Inorganic π Acid Ligands: Dioxygen and dinitrogen, nitrosyl, tertiary phosphines and arsines as ligands. Complexes of σ donor ligands: Transition metal alkyls, alkynyls, carbenes and carbines.

Unit II **Lectures:10**

π complexes of unsaturated molecules: Preparation, bonding and structure of alkene, alkyne, allyl, dienyl and trienyl complexes; reactions with special reference to organic synthesis.

Unit III **Lectures:12**

Transition organometallic compounds: Transition metal compounds with bonds to hydrogen, boron, silicon

Unit IV **Lectures:10**

Transition metal compounds in catalysis: Hydrogenation, hydroformylation and polymerization; Wacker Process.

Unit V **Lectures:12**

Transition metal Compounds with M-H bonds: Metal hydrides (classical and non classical). Agostic Interaction. Application of NMR in studying hydrido complexes.

Teaching Learning Process:

- White board and marker teaching.
- Transaction through an intelligent mix of conventional and modern methods.
- Learning through quiz design.
- Class interactions and discussions

- ❖ Problem solving to enhance comprehension.
- ❖ Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *Advanced Inorganic Chemistry, F.A. Cotton, G. Wilkinson, John Wiley and Sons, NY.*
2. *The Organometallic Chemistry of Transition Metals, R. H. Crabtree, John Wiley.*
3. *Principles and Applications of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegedus, J.R. Norton, R.G. Finke, Univ. Sci. Books, Mill Valley. California.*

Inorganic Chemistry
Paper - III
Techniques in Inorganic Chemistry-S- lll (CHE-303l)
Total Lectures – 54 Credits: 3

Course Objective- To impart knowledge about fundamental understanding on the principle and operation of techniques used for the structural characterization inorganic compounds.

Course Outcome- At the end of course student is expected to understand:

- ❖ Electron Microscopy- SEM and TEM
- ❖ Electron Microscope AFM and STM
- ❖ Photochemistry of Transition Metal complexes
- ❖ Electrochemical Methods: Cyclic voltammetry.
- ❖ Voltammetry and coulometry

Unit I **Lectures: 11**

Electron Microscopy- SEM (Scanning electron microscopy), and TEM (Transmission electron microscopy).

Unit II **Lectures: 11**

Electron Microscope AFM (Atomic force microscopy) STM (Surface tunneling microscopy).

Unit III **Lectures: 10**

Photochemistry of Transition Metal complexes- Photoreactions of inorganic complexes.

Unit IV **Lectures: 10**

Electrochemical Methods- Cyclic voltammetry.

Unit V **Lectures: 12**

Differential pulse voltammetry, anodic stripping voltammetry, chronoamperometry, coulometry.

Teaching Learning Process:

- White board and marker teaching
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material –

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (Names of Publishers may vary as per copyright status)

1. *E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, Structural Methods in Inorganic Chemistry, 1st Edn.(1987), Blackwell Scientific Publications, Oxford, London.*

2. *R. S. Drago, Physical Methods in Chemistry, International Edition (1992), Affiliated East- West Press, New Delhi.*
3. *K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 4thEdn.(1986), John Wiley & Sons, New York.*
4. *W. Kemp, Organic Spectroscopy, 3rd Edn. (1991), Macmillan, London.*
5. *Aruldhas, Molecular Structure and spectroscopy, Prentice Hall of India Pvt. Ltd., New Delhi*

Inorganic Chemistry Laboratory
Credits-3

Course Objective: To develop experimental skills of various separation techniques.

Course Outcome: At the end of the course, the learners should be able to separate Inorganic mixtures using chromatographic techniques

1. Separation of a Mixture of Cations/Anions by Paper Chromatographic technique Using Aqueous/Non-aqueous Media:
   Pb^{2+} and Ag^{+} (aqueous and non-aqueous media)
   Co^{2+} and Cu^{2+} (non aqueous media)
   Cl^{-} and I^{-} (aqueous – acetone media)
   Br^{-} and I^{-} (aqueous – acetone media)

2. Ion-exchange Method of Separation
   Separation of Zn^{2+} and Mg^{2+} on an anion exchanger
   Separation of Co^{2+} and Ni^{2+} on an anion exchanger

Suggested reading: Lab manual

Teaching Learning Process:

- ❖ Hands-on laboratory exercises.
- ❖ Conventional teaching learning method.
- ❖ Engaging students in collaborative learning.

Assessment Methods:

- ❖ Continuous evaluation of laboratory work and record file.
- ❖ Oral assessment, quizzes.
- ❖ Presentation on good lab practices.
- ❖ Semester end University examination

Organic Chemistry
Paper - I
Bioorganic and Medicinal Chemistry-S-1 (CHE-301O)
Total Lectures – 54 Credits: 3

Course Objective- Fundamental understanding on the role of enzymes in biological system, mechanism of enzyme action, biological activity and theories of drug and vitamins.

Course Outcome- At the end of course student is expected to understand

- Basics of enzymes activity
- Mechanism of Enzyme Action
- Chemical structure and biological activities and theories of drug action
- Local anti-infective drugs, psychoactive drugs
- Biological action of vitamins and hormones

Unit I **Lectures:10**

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

Unit II **Lectures:8**

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 III **Lectures:16**

Relationship of chemical structure and biological activities and theories of drug action. Detailed study of following classes:
Antineoplastic Agents: Introduction, cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotics and mitoptic inhibitors. Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, amustards, and 6- mercaptopurine products.
Cardiovascular Drugs: Cardiovascular diseases, drug inhibition of peripheral sympathetic function. Direct acting arteriolar dilators. Synthesis of amyl nitrate, hydralaxine, verapamil, methyldopa and diazoxide propanol.

Unit IV **Lectures:12**

Local Anti-infective Drugs- Antitubercular drugs and Antimalerial drugs: Introduction and general mode of action. Study of sulphonamides, ciprofloxacin, norfloxacin,, amino salicylic acid.

Psychoactive Drugs: CNS depressants general anaesthetics, hypnotics, sedatives, anti-anxiety drugs, benzodiazepines. Antipsychotic drugs: diazepam, alprazolam, trimethadione, barbiturates and glutethimide.
Antibiotics: Penicillin G, chloramphenicol, cephalosporin, tetracycline and streptomycin.

Unit V **Lectures:8**

Vitamins and Hormones- Detailed study of chemistry of Vit. B_1, Vit. C_1, Pantothenic acid, Biotin (Vitamin H) and α-tocopherol (Vitamin E). Biological action of vitamins.
Insect hormones : Pheromones and Juvenile hormones; Plant hormones: Gibberellins.

Teaching Learning Process

- White board and marker teaching.
- Teaching Learning Process for the course is visualized as largely student-focused.
- Learning through quiz design.
- Class interactions and discussions
- Problem solving to enhance comprehension.
- Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Introduction to Bioorganic Chemistry and Chemical Biology, David Van Vranken, Gregory A, Garland Science (Taylor & Francis).*
2. *Natural Products Chemistry, Jagdamba Singh, Pragati Prakashan.*
3. *Chemistry of Natural Products, R.H. Thomson, Wiley, New York.*
4. *Organic Chemistry, Volume 2: Stereochemistry and the Chemistry Natural Products, I.L.Finar, Pearson Education India.*

Organic Chemistry Paper - II
Organic Reactions Mechanisms-S-II (CHE-302O)
Total Lectures – 54 Credits: 3

Course Objective: To impart knowledge about the mechanism involved in molecular rearrangement, various oxidative, reductive and organometallic reagents in organic reactions.

Course Outcome- At the end of course student is expected to understand

- Molecular rearrangements to electron deficient carbon atom
- Molecular rearrangements to electron deficient nitrogen atom
- Different oxidative processes in organic reactions
- Different reductive processes.
- Organometallic Reagents

Unit I **Lectures:10**

Molecular Rearrangements I:
1. Migration to electron deficient carbon atom - Pinacole-Pinacolone rearrangement, Wagner- Meerweian rearrangement, Tiffenev-Demjanov ring expansion, Dienone-Phenol rearrangement, Benzil-Benzilic acid rearrangement, Favorski rearrangement.

Unit II **Lectures:10**

Molecular Rearrangements II:
1. Migration to electron deficient nitrogen atom- Wolf, Hofmann, Curtius, Losen, Schmidt, Beckmann rearrangement.
2. Migration to electron deficient oxygen atom - Baeyer-Villiger rearrangement.
3. Stevens, Witting, Neber rearrangements and rearrangement of amino ketones.

Unit III **Lectures:12**

Oxidation- Introduction, Different oxidative processes. Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated and unactivated) Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids, amines, hydrazines, and sulphides. Oxidations with ruthenium tetraoxide, iodobenzene diacetate and thallium. (III) Nitrate.

Unit IV **Lectures:10**

Reduction- Introduction, Different reductive processes. Alkanes, alkenes, alkynes, and aromatic rings. Carbonyl compounds-aldehydes, ketones, acids and their derivatives. Epoxides - Hydrogenolysis.

Unit V **Lectures:12**

Organometallic Reagents- Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details. Group I and II metal organic compounds: Li, Mg, Hg, Cd, Zn and Ce Compounds.

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Advanced Organic Chemistry, Jagdamba Singh, Pragati Prakashan.*
2. *Reactions, Rearrangements and Reagents, S.N. Sanyal, Bharati Bhawan Publishers & Distributors.*
3. *Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.*
4. *Advanced Organic Chemistry Part A: Structure and Mechanisms, Francis A. Carey, Richard J.Sundberg, Springer.*
5. *A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.*
6. *Structure and Mechanism in Organic Chemistry, C.K. Ingold, Comell University Press.*
7. *Organic Chemistry, R.T. Morrison, R.N. Boyd, Prentice-Hall.*
8. *Modern Organic Reactions, H.O. House, Benjamin.*
9. *Organic Reactions and Their Mechanisms, P.S.Kalsi, New Age International,*
10. *Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan.*

Organic Chemistry
Paper - III
Organic Photochemistry and Pericyclic Reactions- S-III (CHE-303O)
Total Lectures – 54 Credits: 3

Course Objectives: To aware the student about the photochemical reactions of carbonyl, unsaturated & aromatic system, pericyclic reactions and sigmatropic reaction.

Course Outcome- At the end of course student is expected to understand

- Photochemistry of Carbonyl Compounds
- Photochemistry of unsaturated system
- Photochemistry of aromatic compounds
- Pericyclic Reactions
- Sigmatropic rearrangements

Unit I **Lectures:10**

Organic Photochemistry I- Photochemistry of Carbonyl Compounds: Photochemistry of enones, hydrogen abstraction, rearrangements of α, β unsaturated ketones and cyclohexadienones, photochemistry of p-benzoquniones.

Unit II **Lectures:13**

Organic Photochemistry II- Photochemistry of unsaturated system: Olefins, cis-trans isomerization, dimerization, hydrogen abstraction and additions. Acetylenes-dimerization, Dienes-photochemistry of 1, 3-butadiene, (2+2) additions leading to cage structures, photochemistry of cyclohexadienes.

Unit III **Lectures:08**

Organic Photochemistry III- Photochemistry of aromatic compounds-exited state of benzene and its 1, 2 and 1, 3-shifts, Photo-Fries rearrangement, Photo-Fries reaction of anilides, photosubstitution reaction of benzene derivatives. Photolysis of nitride esters and Barton reaction.

Unit IV **Lectures:15**

Pericyclic Reactions- Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene and allyl system. Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions-conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloadditions-antrafacial and suprafacial additions. 4n and 4n+2 systems, 2+2 addition of ketenes, 1, 3 dipolor cycloadditions and cheleotropic reactions.

Unit V **Lectures:08**

Sigmatropic rearrangements- Suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, retention and inversion of configuration, (3,3) and (5,5) sigmatropic rearrangements. detailed treatment of Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Teaching Learning Process

- White board and marker teaching.
- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Learning through quiz design.
- Class interactions and discussions
- Problem solving to enhance comprehension.
- Revising and asking questions at the end of class.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Photochemistry and Pericyclic Reactions, Jagdamba Singh,Jaya Singh, New Age International*
2. *Reaction Mechanism in Organic Chemistry, S. M. Mukherjee, S.P. Singh, Macmillan India Ltd., New Delhi.*
3. *Pericyclic Reactions, S.M. Mukherjee, S.P. Singh, MacMillan India, New Delhi.*
4. *Advanced Organic Chemistry / Organic Synthesis, Jagdamba Singh, L D S Yadav, Pragati Prakashan,*
5. *Pericyclic Reactions, I. Fleming, Oxford University Press, Oxford.*
6. *Molecular Orbitals and Organic Chemical Reactions, Ian Fleming, Wiley.*

Organic Chemistry Laboratory

Credits-3

Course Objective: To develop experimental skills of Synthesis, separation, estimation using UV-Visible spectrophotometric method and structure elucidation.

Course Outcome: At the end of the course, the learners should be able to synthesize, separate and identify organic compounds, verify Lamberts Beer's law and estimation using spectrophotometric techniques

1. Synthesis of organic compounds involving several stages.
2. Separation and identification of organic compounds using physical methods from the organic mixtures.
3. Structure elucidation of compound from its spectrum.
4. Verification of Lambert Beer's Law using bromocresol green reagent.
5. Estimation of carbohydrates, protein, amino acids, ascorbic acid, blood cholesterol and aspirin in APC tablets by UV-Visible spectrophotometric method.

Suggested reading: Lab manual

Teaching Learning Process

- ❖ Hands-on laboratory exercises.
- ❖ Conventional teaching learning method.
- ❖ Engaging students in collaborative learning.

Assessment Methods:

- ❖ Continuous evaluation of laboratory work and record file.
- ❖ Oral assessment, quizzes.
- ❖ Presentation on good lab practices.
- ❖ Semester end University examination

Physical Chemistry
Paper – I
Molecular Spectroscopy -S-I (CHE-301P)
Total Lectures – 54 Credits: 3

Course Objective: This course is aimed at providing students with qualitative and quantitative knowledge about principles and applications of different spectroscopic techniques in the structure determination of molecules.

Course Outcome- At the end of course student is expected to understand:

- Basic concepts, classification of molecular spectra
- Vibration Rotation Spectra
- Electronic spectroscopy
- NMR spectroscopy
- ESR- Principle

Unit I **Lectures:10**

Molecular Spectra- Basic concepts, classification of spectra, Regions of spectrum
Rotational Spectra: Rigid and non-rigid rotational spectra, selection rule, centrifugal distortion, isotopic shift. Spectra of polyatomic molecules, Inversion and internal rotation.

Unit II **Lectures:10**

Vibration Rotation Spectra: S.H.O., Vibrational energy, Anhormonicity, Rotation-vibration spectra. Selection rule, PQR branches, vibrational spectra of polyatomic molecules.

Unit III **Lectures:10**

Electronic spectroscopy- Frank-Codon principle, Electronic spectra of polyatomic molecules, Charge -transfer spectra. Quantum theory of Raman spectra, Rotational and vibrational Raman Spectra, Resonance Raman spectra, Laser Raman spectra.

Unit IV **Lectures:14**

NMR spectroscopy- Theory relaxation process and chemical shift. Spin-spin splitting. FT-NMR spectroscopy, 2D NMR spectroscopy, NOE, double resonance, COSY, INDOR, CIDNP.

Unit V **Lectures:10**

ESR- Principle, g-factor, ESR of anisotropic system, ZFS, ENDOR, ELDOR. Principle of Mossbauer spectroscopy, Origin of line width, Isomer shift, Quadruapole effect.

Teaching Learning Process

- ❖ White board and marker teaching.
- ❖ Transaction through an intelligent mix of conventional and modern methods.
- ❖ Learning through quiz design.
- ❖ Class interactions and discussions
- ❖ Revising and asking questions at the end of class.
- ❖ Problem-solving method

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *J.M. Hollas, Modern Spectroscopy, 4th edition (2004), John Wiley and Sons, Chichester.*
2. *C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.*
3. *E.M. Mc Cash, Surface Chemistry, Oxford University Press, Oxford (2001).*
4. *A.K. Cheetham and P Day, Solid State Chemistry Techniques, Oxford Univ. Press, Oxford (1988).*
5. *Joseph R. Lakowicz, Fluorescence Spectroscopy, 2nd edition, Plenum Press, New York. (1999).*

Physical Chemistry
Paper – II
Electrochemistry -S-II (CHE-302P)
Total Lectures – 54 Credits: 3

Course Objective: The objective of this course develop fundamental understanding to the students about the concepts of conductance and its application, Debye Huckel theory, kinetics of electrode reaction, Bio electrochemistry, ion-sensors and fuel cell technology.

Course Outcome- At the end of course student is expected to understand:

- Basics of electrolytic conductance
- Non-ideal systems
- Debye-Huckel theory of activity coefficients
- Bioelectrochemistry- Bioelectrodics
- Fuel cell technology

Unit I **Lectures:10**

Ionic conductance, Molar conductance, Cell constant, Migration of ions, Transport number and and its determination (Hittorf`s and moving boundary method), Ostwald`s dilution law, Conductometric titration, Potentiometric titration, Grotthus mechanism, Debye-Huckel theory of strong electrolytes, Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect.

Unit II **Lectures:08**

Non-ideal systems- Excess function for non-ideal solutions. Activity, activity coefficient, Debye- Huckel limiting law, Bjerrum`s theory, Application of Phase rule to three component systems, second order phase transition

Unit III **Lectures:10**

Debye-Huckel theory of activity coefficients, Bjerrum theory of ion association, Dynamic electrochemistry- Electrical double layer, Electrode kinetics, Rate of charge transfer, Current density, Butler- Volmer equation,

Unit IV **Lectures:14**

Bioelectrochemistry- Bioelectrodics, membrane potentials, simplistic theory, modern theory, electrical conductance in biological organism: electronic, protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

Unit V **Lectures:12**

Fuel cell technology- Fuel cell, Simple Grove's fuel cell, efficiency of fuel cell, SOFC. Electrochemical sensors: Potentiometric sensors, Ion-selective electrodes, Membrane electrodes, Amperometric sensors, Clark and Enzyme electrodes).

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Activating prior knowledge by Random questioning.
- ❖ Real life example to lifelong learning
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods:

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material –

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Physical Chemistry, P.W. Atkins, ELBS.*
2. *Physical Chemistry, Levine*
3. *Physical Chemistry, G. W.Castellan.*
4. *Modern Electrochemistry, Vol. 1, Vol. 2A and Vol. 2 B, J.O'M. Bockris, A.K.N. Reddy,Plenum Press, New York.*
5. *Electrochemical Methods: Fundamentals and Applications, A.J. Bard, L.R. Faulkner, John Wiley and Sons, New York*

Physical Chemistry
Paper – III
Quantum Chemistry -S-III (CHE-303P)
Total Lectures – 54 Credits: 3

Course Objective: The objective of this course is to introduce the students to the concepts and methodology of quantum mechanics, its applications to molecular bonding.

Course Outcome- At the end of course student is expected to understand:

- ❖ Review of classical mechanics
- ❖ Concept of operators in quantum mechanics
- ❖ Quantum mechanical approaches to molecular Bonding
- ❖ LCAO-MO treatment of hydrogen molecule ion
- ❖ Huckel molecular orbital theory and its application

Unit I **Lectures:9**

Review of classical mechanics. Wave-particle duality and Uncertainty principle. Origin of quantum theory, Black body radiation, Wien and Rayleigh Jeans laws. Planck‘s law and energy of harmonic oscillator.

Unit II **Lectures:11**

Concept of operators in quantum mechanics- operators for velocity, kinetic energy, momentum and angular momentum. Laplacian and Hamiltonian operator, Schrödinger‘s equation and its solution for Hydrogen atoms. Derivation of Heisenberg‘s uncertainty principle.

Unit III **Lectures:12**

Quantum mechanical approaches to molecular Bonding, Born-Oppenheimer approximation. Valence bond theory and molecular orbital theories. Valence bond theory and its application to homonuclear (Hydrogen) and heteronuclear (HCI) diatomics.

Unit IV **Lectures:08**

LCAO-MO treatment of hydrogen molecule ion.Comparative study of MO and VB theory. The variation theorem, linear variation principle. Perturbation theory (First order and nondegenerate).Applications of variation method and perturbation theory to the Helium atom.

Unit V **Lectures:14**

Huckel molecular orbital theory and its application to hybridization systems (ethylene, butadiene, allyls and benzene).Calculation of delocalization energy. Physical significance of charge density and bond order. Calculation of bond length. Perturbation methods in LCAO- MO theory. Extended Huckel molecular orbital theory and SCF-MO method.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Active participation of students in the classroom through regular presentations on curriculum-based topics.
- Problem-solving method

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material –

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Introduction to Quantum Chemistyry, A.K. Chandra, Tata Mc Graw Hill.*
2. *Quantum Chemistry, Ira N. Levine, Prentice Hall.*
3. *Introduction to Quantum Chemistry-R.K. Prasad, New Age Publication.*
4. *Physical Chemistry, P.W. Atkins, ELBS.*
5. *Physical Chemistry, Levine*
6. *Physical Chemi stry, G. W.Castellan.*

Physical Chemistry Laboratory
Credits: 3

Course Objective: To develop Hands on experience on handling and functioning of laboratory instruments to impart experiential learning. .

Course Outcome- At the end of course student is expected to understand:

- ❖ Review of classical mechanics
- ❖ Concept of operators in quantum mechanics
- ❖ Quantum mechanical approaches to molecular Bonding
- ❖ LCAO-MO treatment of hydrogen molecule ion
- ❖ Huckel molecular orbital theory and its application

1. Oxidation of diols by cerium(IV) sulphate in acidic medium catalyzed by rhodium(III) chloride.
2. Kinetics of oxidation of ketones by Ce(IV) sulphate in acidic medium catalysed by Ir(III) chloride .
3. Conductometry/Potentiometry/pHmetry titration.
4. Determination of viscosity and density of aqueous solution of glucose/sucrose/urea at different temperatures and to calculate apparent and partial molar volume.
5. Determination of molecular weight of some electrolytes and nonelectrolytes cryoscopically.

Teaching Learning Process:

- ❖ Hands-on laboratory exercises.
- ❖ Conventional teaching learning method.
- ❖ Engaging students in collaborative learning.

Assessment Methods

- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Presentation on good lab practices.
- Semester end University examination.

Suggested reading: Lab manual

ELECTIVE PAPERS - III

Paper - IV

Chemistry of Macromolecules (CHE-304)

Total Lectures – 54 Credits: 3

Course Objective: Fundamental understanding on macromolecules and methods for their determination,

Course Outcome- At the end of course student is expected to understand:

- Basics concept of macromolecules
- Weight determination methods of macromolecules
- Thermodynamics of polymers
- Glass transition temperature
- Mechanism and methods of polymerization

Unit I **Lectures:10**

Basic concepts - classification, nomenclature, molecular weights, molecular weight distribution, glass transition, degree of crystallinity, morphology, and viscosity-molecular weight, mechanical property - molecular weight relationships.

Unit II **Lectures:10**

Molecular weights and Methods of determination, molecular weight distribution, size and shape of macromolecules. Intrinsic viscosity, Mark-Houwink relationship.

Unit III **Lectures:12**

Chain structure and configuration, conformation, size of an ideal chain (freely jointed chain and other models), Real chains, Flory theory. Thermodynamics of polymer solutions. Molecular motion (self-diffusion, hydrodynamic radius, Rouse Model, Zimm Model, entangled polymer dynamics and de Gennes reptation model).

Unit IV **Lectures:10**

Glass transition temperature – elementary theories and methods of determination. Variation of glass transition with structure. Rubber elasticity - concepts, thermodynamic equation of state. Elementary theories of viscoelasticity (Maxwell, Voight).

Unit V **Lectures:12**

Mechanisms and Methods of Polymerization - Step (condensation) polymerization - Description - Reactivity Functional Groups - Kinetic and thermodynamic considerations - Molecular weight distribution. Chain polymerization, controlled radical polymerizations (INIFERTER, ATRP, RAFT, SET). Living Polymerizations. Ziegler-Natta and metathesis polymerizations.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Recommended

1. *R. J. Young and P. A. Lovell, Introduction to Polymers, 2nd Edition, Chapman and Hall, 2002.*
2. *F. W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley, 1994.*
3. *V. R. Gowariker, N. V. Viswanathan, Jayadev Sreedhar, New Age International*
4. *(P) Ltd, 2005.*
5. *G. Odian, Principles of Polymerization, Fourth edition, Wiley-Interscience, 2004.*
6. *L. H. Sperling, Introduction to Physical Polymer Science, Wiley- Interscience, 1986.*
7. *M. Rubinstein and R. A. Colby, Polymer Physics, Oxford University Press, 2003.*

Nanocatalysis (CHE-305)
Total Lectures – 54 Credits: 3

Course Objective: The aim of this course is to introduce materials at nanoscale, their preparation, characterization and applications.

Course Outcome- At the end of course student is expected to understand:

- Introduction to nanomaterials
- Chemical activity and selectivity of nanocatalyst
- Chemical reaction and catalytic process
- Mode of catalysis action
- Techniques of properties determination

Unit I **Lectures:12**

Introduction, classification of nanomaterials, preparation and characterization, different types of nanostructures- nanoparticles, nanoclusters, nanowires, nanorods, nanofilms, nanotubes, C-nanotubes etc

Unit II **Lectures:08**

Chemical activity, selectivity and specificity of nanocatalyst, role of size, shape and surface area of nanoparticles in catalysis. Bulk and nanoscale surfaces, chemical reactions on point defects on oxide surfaces.

Unit III **Lectures:12**

Chemical reactions and catalytic processes on free and supported clusters, catalytic processes on free metal clusters, chemical reactions and catalytic cycles on supported clusters. single atoms on oxide surfaces, size -selected clusters on oxide surfaces, size -distributed clusters and oxide surfaces.

Unit IV **Lectures:10**

Mode of action of catalysts, classification & comparison-homogeneous and heterogeneous catalysis, Mechanism: intermediate steps and kinetics of homogeneous and heterogeneous processes, Langmuir Hinshelwood mechanism for nanocatalyst.

Unit V **Lectures:12**

Techniques to determine the properties of nanocatalysts like TEM, XRD. Applications of nanocatalysis in pharmaceutical, in synthesis of fine chemicals, in medicine for protection of environment etc.

Nuclear Chemistry and Radioanalysis (CHE-306)
Total Lectures – 54 Credits: 3

Course Objective: The Objective of this course is to provide fundamental knowledge of nuclear chemistry.

Course Outcome- At the end of course student is expected to understand:

- Fundamentals of nuclear chemistry
- Types of nuclear reactions
- Interaction of radiation with matter
- Analysis techniques
- Radiocarbon and dating

Unit I **Lectures:12**

Fundamentals of Nuclear Chemistry, Stability of nucleus, Properties of nucleus, N uclear Models.

Unit II **Lectures:10**

Nuclear reactions – fission, fusion, spallation, fragmentation, stripping and pick up reactions, photonuclear and thermonuclear reactions.

Unit III **Lectures:14**

Interaction of Radiation with matters- Counting techniques and counting statistics, Ionisation, Proportional GM and scintillation counters, counting errors and corrections, Chemical Dosimetry.

Unit IV **Lectures:10**

Activation analysis, tracer techniques and dilution analysis, radiometric titrations.

Unit V **Lectures:08**

Radiocarbon and other dating.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Real life example to lifelong learning
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Recommended

1. C. A. Vincent Modern Batteries, Edward Arnold, 1984.
2. R. Narayanan and B. Viswanathan, Chemical and Electrochemical energy systems, Orient Longmans, 1997.
3. K. Sriram, Basic Nuclear Engineering, Wiley Eastern, 199

SKILL DEVELOPMENT - III

Paper - V

Hand Made Soap/Detergent Making (CHE-307)

Total Lectures – 36 Credits: 2

Course Objective: This course is designed to provide the student knowledge of handmade soaps/ detergent making.

Course Outcome- At the end of course student is expected to understand:

- ❖ Types of cleaning agents
- ❖ Properties of cleaning agents
- ❖ Technical skill of soap/detergent making
- ❖ Marketing of soap and allied products

1. Types of cleaning agents:
   (1) Toilet Soaps (2) Washing Soap (3) Detergent Powder - High and Medium quality (4) Dish Wash Powder (5) Cleaning Lotion (6) Liquid Soap.
2. Properties of cleaning agents
3. Technical skill of soap/detergent making
4. Marketing of soap and allied products

Teaching Learning Process:

- ❖ White board and marker teaching
- ❖ Class interactions and discussions

Assessment Methods:

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material –

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

UNIVERSITY ELECTIVE – III

(Not for chemistry students)
Paper - VI
Environmental Chemistry (CHE-308)
Total Lectures – 54 Credits: 3

Course Objective: This course is designed to make them aware about the concepts of different types of pollution and its effect.

Course Outcome- At the end of course student is expected to understand:

- Introduction to Environmental Chemistry
- Natural cycles of environment
- Chemical Toxicology
- Air Pollution
- Water pollution.

1. Introduction to Environmental Chemistry- Concept and scope of environmental chemistry, terminology and nomenclatures, Environmental segments.
2. The natural cycles of environment (Hydrological, Oxygen, Nitrogen)
3. Toxic chemicals in the environments, Impact of toxic chemicals on enzymes, Biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, nitrogen oxides, sulphur oxides.
4. Air Pollution- Particulates, Aerosols, SOx, NOx, COx and hydrocarbon, smog, Air-quality standards
5. Water Pollution- Water-quality parameters and standards: physical and chemical parameters, Dissolved oxygen, BOD, COD, TDS, Chemical speciation (Pb, As, Hg)

Teaching Learning Process:

- White board and marker teaching
- Class interactions and discussions
- Power point presentations.
- Interactive sessions.
- To get recent information through the internet.

Assessment Methods:

- In text question,
- Poster presentation/Oral test
- Class
- Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material –

- Text Books
- Class notes

- Video links
- Digital library links
- NGB e-library

Books Recommended

1. *G.W. Vanloon, S.J. Duffer, Environmental Chemistry - A Global Perspective, Oxford University Press (2000).*
2. *F.W. Fifield and W.P.J. Hairens, Environmental Analytical Chemistry, 2nd Edition (2000), Black Well Science Ltd.*
3. *Colin Baird, Environmental Chemistry, W.H. Freeman and Company, New York (1995).*
4. *A.K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd.,New Delhi.*
5. *Peter O. Warner, Analysis of Air Pollutants, 1st Edition (1996), John Wiley, New York.*
6. *S.M. Khopkar, Environmental Pollution Analysis, 1st Edition (1993), Wiley Estern Ltd., New Delhi.*

SPECIALIZATION PAPERS
SEMESTER IV

Inorganic Chemistry
Paper - I
Spectral Techniques in Inorganic Chemistry-S-IV (CHE-401I)
Total Lectures – 54 Credits: 3

Course Objective: This course aims to provide knowledge on various spectroscopic techniques for chemical analysis of inorganic compound along with the basic principles of instrumentation.

Course Outcome At the end of course student is expected to understand:

- ❖ NMR Spectroscopy
- ❖ Nuclear Spectroscopy
- ❖ Electron Spin Resonance Spectroscopy
- ❖ Infrared and Raman Spectroscopy
- ❖ Mass Spectrometry

Unit **Lectures:12**

Introduction to NMR: Origin of magnetic moments in matter, electronic and nuclear moments, interaction with magnetic field, Larmor equation - conditions for magnetic resonance absorption, relaxation times, line widths and line shapes, ring currents, diamagnetic anisotropy, spin-spin splitting, high resolution NMR spectra of simple molecules.

Unit II **Lectures:10**

Nuclear Spectroscopy – (ii) Multinuclear NMR of Metal nuclei.^{31}P, ^{9}F, ^{27}Al, ^{11}B, ^{119}Sn.

Unit III **Lectures:12**

Electron Spin Resonance Spectroscopy: Basic principle, Hyperfine Splitting (isotropic systems); the g value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Karamer's degeneracy); Electron- electron interactions, Anisotropic effects (the g value and the hyperfine couplings); Structural applications of transition metal complexes.

Unit IV **Lectures:13**

Rotational, Vibrational and Electronic spectroscopy: Electromagnetic radiation, interaction of electromagnetic radiation with matter, quantum mechanical approach transition probabilities: Einstein coefficients, pure vibrational and rotational spectra, selection rules, vibrational and rotational spectra of polyatomic molecules, normal modes, an anhorminicity, selection rules.

Unit V **Lectures:07**

Mass Spectrometry: Basic Principle, Fragmentation pattern and Fingerprint applications in the interpretation of Mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (ESI, TOF and FAB)

Teaching Learning Process

The teaching learning process will involve the blended learning technique along with marker and white board method wherever required. Students are encouraged to participate actively in the classroom through regular presentations/question design on curriculum based topics.

Assessment Methods

Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (*Names of Publishers may vary as per copyright status):*

1. *E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, Structural Methods in Inorganic Chemistry, 1st Edn.(1987), Blackwell Scientific Publications, Oxford, London.*
2. *R. S. Drago, Physical Methods in Chemistry, International Edition (1992), Affiliated East- West Press, New Delhi.*
3. *K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination*

Compounds, 4thEdn.(1986), John Wiley & Sons, New York.
4. *W. Kemp, Organic Spectroscopy, 3rd Edn. (1991), Macmillan, London.*
5. *G. Aruldhas, Molecular Structure and spectroscopy, Prentice Hall of India Pvt. Ltd., New Delhi (2001).*

Inorganic Chemistry
Paper - II
Group theory and Molecular Spectroscopy-S-V (CHE-402I)
Total Lectures – 54 Credits: 3

Course Objective: This course aimed to provide the fundament knowledge about the Group theory, Rotational, Vibrational, Electronic, NMR, EPR, NQR and Mossbauer spectroscopy.

Course Outcome- At the end of course student is expected to understand

- Group Theory
- Infrared and Raman Spectroscopy
- Classical and quantum theory of Raman effect
- Introduction to NMR
- EPR, NQR and Mossbauer spectroscopic techniques

Unit I **Lectures:14**

Group Theory: Introduction, Molecular symmetry and point groups, symmetry elements and operators, classes of symmetry operation, symmetry classification of molecules. Matrix Representation of symmetry operations, representation of groups, character, reducible and irreducible representations, great orthogonality theorem. character tables, symmetry properties of Hamiltonian operator, mutual exclusion principle.

Unit II **Lectures:08**

Infrared and Raman Spectroscopy: Basic Principle, Fundamental modes, Factors affecting vibrational frequency, Applications of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB2, AB3 and AB4 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, sulphate and ureas).

Unit III **Lectures:10**

Raman Effect: classical and quantum theory of Raman effect, rotational and vibrational Raman spectra. Franck-Condon principle, transition moments, assignment of electronic transitions of N_2. H_2O and formaldehyde using group theory.

Unit IV **Lectures:12**

NMR Spectroscopy (i)- Use of Chemical shifts and spin-spin couplings for structural determination; Double resonance, and Dynamic processes in NMR; Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in ^{13}C NMR; Use of Chemicals as NMR auxiliary reagents (shift reagents and relaxation reagents); 1H NMR of paramagnetic substances.

Unit V **Lectures:10**

Other Resonance Spectroscopy Methods:-EPR, NQR and Mossbauer spectroscopic techniques - Electron spin resonance: g value, hyperfine structure, ESR of organic free radicals, ESR of inorganic ions, ESR of simple free radicals in solutions - NQR. The principles of Mossbauer spectroscopy. Origin of isomer shifts, quadrupole splitting and h. f. s.

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Activating prior knowledge by Random questioning.
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Theoretical Inorganic Chemistry by M.C. Day and J. Selbin,*
2. *Modern Aspects of Inorganic Chemistry by H.J. Emelens and A.G. Sharp.. (Van).*
3. *Text book of Inorganic Chemistry by P.L. Soni (S. Chand)*
4. *Inorganic Chemistry by Shriver & Atkins*
5. *F.A Cotton and G Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons New York.*

Inorganic Chemistry
Paper - III
Scope of Chemical Biology-S-VI (CHE-403I)
Total Lectures – 54 Credits: 3

Course objective: To develop an understanding about the biologically significant

complexes of metal and their role in biological system.

Course Outcome- At the end of course student is expected to understand:

- Role of Metal Ions in Biological Systems
- Complexes of Biological Significance:
- Metalloproteins
- Metallo enzymes
- Copper containing Enzymes

Unit I **Lectures:08**

Role of Metal Ions in Biological Systems: Photosystems; nitrogen fixation, Na+ / K+ pump.

Unit II **Lectures:08**

Complexes of Biological Significance: Metal complexes of porphyrins and phthalocyanine, Vitamin B12 and B6; chlorophylls.

Unit III **Lectures:14**

Metalloproteins: Function, Electronic structure, bonding and stereochemistry of the active site – Natural oxygen carrying proteins – Haemoglobin, Myoglobin, Hemerythrin and Hemocyanin Electron Transport Protein – (a) Iron – sulfur Proteins – Rubredoxin and Ferredoxins
(b) Cytochromes (types a, b and c)

Unit IV **Lectures: 12**

Metallo enzymes - Mo-containing Enzymes – Nitrogenase; Xanthine Oxidase, sulphite, Oxidase and Nitrate reductase (b) Iron-containing Enzymes – cytochrome – c- oxidase, catalases, Peroxidases, cytochrome-p-450

Unit V **Lectures: 12**

Copper – containing Enzymes – Superoxide dismutase (SOD), Bovine Superoxide dismutase (BOD), ascorbic acid oxidase and (b) Zinc – containing Enzymes carboxy – peptidase A and B; carbonic anhydrase and Urease.

Teaching Learning Process

The teaching learning process will involve the blended learning technique along with marker and white board method wherever required. Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.

Assessment Methods

Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester

university examination will be held for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *M. N. Hughes, Inorganic Chemistry of Biological Processes, 2nd Ed.(1981), John-Wiley & Sons, New York.*
2. *2.W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide, Wiley, New York (1995).*
3. *3.S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Books, (1994).*
4. *4.I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi (1998).*

Organic Chemistry
Paper - I
Concepts in Organic Synthesis- S-IV (CHE-401O)
Total Lectures – 54 Credits: 3

Course Objective: Aim of this course is to aware the students synthetic strategies of organic synthesis, reagents used in synthesis and their synthetic application.

Course Outcome- At the end of course student is expected to understand:

- Disconnection Approach.
- Synthetic Strategies.
- Stereochemistry in organic synthesis.
- Reagents in Organic Synthesis.
- Selective organic name reaction and their synthetic applications.

Unit I **Lectures: 08**

Disconnection Approach: General introduction to synthons and Synthetic equivalents, Disconnections, (C-C, C-S, C-O, bonds), Functional group interconversion, chemoselectivity, cyclisation reaction, choosing synthetic route for small and large scale synthesis.

Unit II **Lectures:12**

Synthetic Strategies: (a) For formation of carbon-carbon bond (b) For formation of carbon-nitrogen bond (c) Formation of carbon-halogen bond (d) Ring Synthesis and (e) Multistep Synthesis.

Unit III **Lectures:12**

Protecting Groups: Principle of protection of alcoholic, amino, carbonyl and carboxylic groups.
Stereochemistry in organic synthesis: Stereoselectivity and stereospecificity. Regioselectivity and regiospecificity: Assymmetric synthesis- Sharpless asymmetric epoxidation. An introduction to computer aided designing of organic synthesis.

Unit IV **Lectures: 12**

Reagents in Organic Synthesis:
(i) Complex metal hydrides. (ii) Gilman's reagent. (iii) Lithium disopropyl amide (LDA). (iv) Dicyclohexylcarbodimide
(DCC). (v) 1,3-Dithiane (Reactivity Umpolung). (vi) Trimethylsily iodide. (vii) Tri n-butyltin hydride. (viii) Crown ethers. (ix) Merrifield resin. (x) Wilkinson's Reagent. (xi) Peterson's Synthesis (xii) Organic per acids. (xiii) Baker's yeast.

Unit V **Lectures: 10**

Selective organic name reaction and their synthetic application: (i) Stork Enamine reaction. (ii) Favorskii reaction. (iii) Ene Reaction. (iv) Barton Reaction. (v) Hofmann-Loffler-Freytag Reaction. (vi) Shapiro Reaction. (vii) Chichibabin Reaction. (viii) Robinson annulation.
Nitrogen, Sulphur and Phosphorus Ylides: Preparation and their synthetic applications.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan*
2. *Advanced Organic Chemistry, Jagdamba Singh, Pragati Prakashan.*
3. *Organic Chemistry: Concepts and Applications, Jagdamba Singh, Pragati Prakashan.*
4. *Advanced Organic Chemistry Part B: Reaction and Synthesis, Francis A. Carey, Richard J.Sundberg, Springer.*
5. *A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.*
6. *Advanced Organic Chemistry, Arun Bahl, B S Bahl, S Chan.*

Organic Chemistry
Paper - II
Spectroscopic Identification of Organic Compounds S-V (CHE-402O)
Total Lectures – 54 Credits: 3

Course Objective: This course aims to provide knowledge on various spectroscopic techniques for chemical analysis of organic compounds along with the basic principles of instrumentation.

Course Outcome- At the end of course student is expected to understand:

- Fundamental concepts of spectroscopic techniques.
- Nuclear Magnetic Resonance Spectroscopy.
- Carbon-13 NMR Spectroscopy/2-D Spectroscopy.
- Introduction to mass spectrometry.
- Solution of Structural problems by joint application of UV, IR, and NMR.

Unit I **Lectures: 14**

Introduction to spectroscopic techniques: Electromagnetic spectrum, absorption of energy by organic compounds. Types of spectroscopic methods for organic structure elucidation. Applications of UV – Visible and IR spectroscopies in organic structure elucidation. Various electronic transitions (200-800 nm), Beer-Lambert law. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ether's, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds. Effect of hydrogen bonding on vibrational frequencies.

Unit II **Lectures: 10**

Nuclear Magnetic Resonance Spectroscopy- Basic principles. Introduction to NMR techniques. CW and FT NMR techniques. ^{1}H NMR Spectral parameters – intensity, chemical shift, multiplicity, coupling constant. Analysis of first order and second - order spectra. Structure determination of organic compounds by ^{1}H NMR spectra.

Unit III **Lectures: 12**

Carbon-13 NMR Spectroscopy/2-D Spectroscopy- General considerations, chemical shift (aliphatic olefinic, alkyne, aromatic, heteroaromatic and carboynl carbon), coupling constants. Two dimension NMR spectroscopy-COSY, NOESY, DEPT, HMBC and HMQC techniques.

Unit IV **Lectures: 08**

Introduction to mass spectrometry, mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak. Mc Lafferty rearrangement. Nitrogen rule. High-resolution mass spectrometry.

Unit V **Lectures: 10**

Solution of Structural problems by joint application of UV, IR, NMR ^{1}H and ^{13}C) and mass spectroscopy.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Real life example to lifelong learning
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Organic Spectroscopy, L.D.S.Yadav, Springer.*
2. *Elementary Organic Spectroscopy, Y R Sharma, S Chand.*
3. *Spectroscopy of Organic Compounds, P.S.Kalsi, New Age International.*
4. *Application of Absorption Spectroscopy of Organic Compounds, J. R. Dyer, Prentice Hall,New Delhi.*
5. *Spectroscopic Identification of Organic Compounds, R.M. Silverstein, F.X. Webster, John Wiley, New York.*
6. *Spectroscopic Methods in Organic Chemistry, D.H. Williams, I.F. Fleming, Tata- McGraw Hill, New Delhi.*
7. *Organic Spectroscopy, William Kemp, Palgrave Macmillan.*

Organic Chemistry
Paper - III
(Biosynthesis and Chemistry of Natural Products) S-VI (CHE-403O)
Total Lectures – 54 Credits: 3

Course Objective: This course aims to provide knowledge of synthesis of various natural products, Terpenoids, Carotenoids, Alkaloids, Steroids and plant Pigments.

Course Outcome- At the end of course student is expected to understand

- Bio-synthesis of Natural Products
- Terpenoids and Carotenoids
- Alkaloids
- Steroids
- Prostaglandins - Plant Pigments

Unit I **Lectures: 10**

Biosynthesis of Natural Products- The acetate hypothesis, poly β-Ketoacids, Biosynthesis, Biogenesis Primary and Secondary reactions involved in biosynthesis. Biosynthesis of poly-ß-ketoacid
Isoprene rule, mevalonic acid from acetyl Co-enzyme A. Biosynthesis of mono, sesqui, di and triterpenes. Shikimic acid pathway for biosynthesis of aromatic ring.General biosynthesis of alkaloids.

Unit II **Lectures:12**

Terpenoids and Carotenoids: Classification, isoprene rule. Structure determination, stereochemistry, synthesis of the following representative molecules: citral, α terpenol, farnesol, santonin, abietic acid and ß-carotene, menthol. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

Unit III **Lectures:10**

Alkaloids: General methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, Structure, stereochemistry and synthesis of the following: Ephedrine, (+) nicotine, quinine and morphine. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

Unit IV **Lectures:10**

Steroids: Basic skeleton Diel'shyadrocarbon and stereochemistry, structure determination and synthesis of cholesterol, testosterone, estrone and progesterone. For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

Unit V **Lectures:12**

Prostaglandins: Occurrence, nomenclature, classification. Synthesis of PGE2 and PGF2a
Plant Pigments: General methods of structure determination, synthesis of Apigenin, Quercetin Cyanidin Hirsutin. Quercetin-3 glucoside, Diazein and cyanidine-7 glucoside.
For structure elucidation emphasis is to be placed on the use of spectral data wherever possible.

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Activating prior knowledge by Random questioning.
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *Classics in Total Synthesis by K. C. Nicolaou & E. J. Sorensen, VCH, 1996.*
2. *Classics in Total Synthesis II, K. C. Nicolaou & S. A. Snyder, VCH, 2003.*
3. *The Logic of Chemical Synthesis by E. J. Corey & X-M. Cheng.*
4. *Natural Products Chemistry & Applications, Bhat, S.V.; Nagasampagi, B. A. & Meenakshi, S Narosa Publishing House, 2009*
5. *Classics in Stereoselective Synthesis by Carreira, E. M.; Kvaerno, L, Wiley VCH, 2009*

Physical Chemistry
Paper –I
Spectroscopy and Modern Techniques -S-IV (CHE-401P)
Total Lectures – 54 Credits: 3

Course Objective: This course aims to provide knowledge on various techniques of analysis in chemistry along with the basic principles of instrumentation and application.

Course Outcome- At the end of course student is expected to understand

- ❖ Photoelectron Spectroscopy and Related Techniques.

- ❖ Techniques for Studying Surface Structure.
- ❖ LASER and MASER, NQR spectroscopy.
- ❖ Fluorescence techniques.
- ❖ Scanning tunnelling and atomic force microscopy (STM and AFM).

Unit I **Lectures: 12**

Photoelectron Spectroscopy and Related Techniques: Principle and applications to studies of molecules and surface. UPES and XPS Auger electron and X-ray fluorescence spectroscopy (AES and XRF).

Unit II **Lectures:08**

Techniques for Studying Surface Structure: Low energy electron diffraction (LEED), EXAFS and SEXAFS.

Unit III **Lectures:14**

LASER and MASER, NQR spectroscopy, Neutron Diffraction: Principle and applications.

Unit IV **Lectures: 12**

Fluorescence techniques: Steady-state fluorescence spectroscopy. Time-resolved (Time correlated single photon counting-TCSPC) fluorescence spectroscopy. Introduction to Single molecule fluorescence and fluorescence imaging.

Unit V **Lectures:08**

Scanning tunneling and atomic force microscopy (STM and AFM).

Teaching Learning Process

- ❖ White board and marker teaching
- ❖ Activating prior knowledge by Random questioning.
- ❖ Class interactions and discussions
- ❖ Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested (Names of Publishers may vary as per copyright status):

1. *J.M. Hollas, Modern Spectroscopy, 4th edition (2004), John Wiley and Sons, Chichester.*
2. *C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.*
3. *E.M. Mc Cash, Surface Chemistry, Oxford University Press, Oxford (2001).*
4. *A.K. Cheetham and P Day, Solid State Chemistry Techniques, Oxford Univ. Press, Oxford (1988).*
5. *Joseph R. Lakowicz, Fluorescence Spectroscopy, 2nd edition, Plenum Press, New York. (1999).*

Physical Chemistry
Paper – II
Energetics -S-V (CHE-402P)
Total Lectures – 54 Credits: 3

Course Objective: Designed to provide knowledge on thermodynamic functions for non-equilibrium system, ideal and non-ideal system, Nernst heat theorem etc.

Course Outcome- At the end of course student is expected to understand

- ❖ Thermodynamic functions for non-equilibrium states.
- ❖ Transformations of the generalized fluxes and forces.
- ❖ Nernst heat theorem and its application to non- condensed systems.
- ❖ Thermodynamics functions for Ideal and non-ideal solutions.
- ❖ Gibbs-Duhem-Margules equation and its applications

Unit I **Lectures: 10**

Thermodynamic functions for non-equilibrium states, Postulates and methodology, Linear laws, Gibbs equation, Entropy production and entropy flow, Phenamenological equations, Microscopic reversibility and Onsager's reciprocity relations.

Unit II **Lectures: 08**

Transformations of the generalized fluxes and forces, Electrokinetic phenomena, Diffusion, Electric conduction, The stationary non-equilibrium states, States of minimum entropy production.

Unit III **Lectures: 12**

Nernst heat theorem and its application to non- condensed systems. Statements of the third law of thermodynamics. Derivation of unattainability of absolute zero. The relationship between entropy constant and Nernst chemical constant. Applications of the third law.

Unit IV **Lectures: 12**

Ideal and non-ideal solutions, Inter-connection between Raoult's law and Henry's Law, Determination of Partial Molar Properties, Thermodynamic functions of mixing of nonideal solutions, Excess thermodynamic functions.

Unit V **Lectures: 12**

Gibbs-Duhem-Margules equation and its applications, Activity and activity coefficients, Activity coefficients from excess thermodynamic functions, The theory of Van Laar, Scatchard Hildebrand theory, Wilson model and Flory-Huggins theory.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by random questioning.
- Class interactions and discussions

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested*(Names of Publishers may vary as per copyright status):*

1. *J.M. Hollas, Modern Spectroscopy, 4th edition (2004), John Wiley and Sons, Chichester.*
2. *C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.*
3. *E.M. Mc Cash, Surface Chemistry, Oxford University Press, Oxford (2001).*
4. *A.K. Cheetham and P Day, Solid State Chemistry Techniques, Oxford Univ. Press, Oxford (1988).*

5. *Joseph R. Lakowicz, Fluorescence Spectroscopy, 2nd edition, Plenum Press, New York. (1999).*

Physical Chemistry
Paper – III
Chemical Dynamics -S-VI (CHE-403P)
Total Lectures – 54 Credits: 3

Course Objective: To make the student skilful to apply, analyze and evaluate the kinetics of various types of reactions.

Course Outcome- At the end of course student is expected to understand:

- Kinetics of fast reactions.
- Heterogeneous catalysis.
- Comparison of homogeneous and heterogeneous reactions.
- Kinetic of polymerization.
- Coordination polymerization.

Unit I — Lectures: 10

Kinetics of fast reactions: Techniques of study of fast reactions with reference to stop flow, T-Jump, Flash photolysis and relaxation phenomena. Kinetics of oscillating reactions with special reference to Belousov-Zhabotinskii mechanism (B-Z mechanism).

Unit II — Lectures: 14

Heterogeneous catalysis, Kinetics and mechanism of reactions on surface, Mechanism of surface reactions, Uni and bi-molecular surface reactions, Langmuir-Hinshelwood mechanism, Langmuir-Rideal mechanism, Inhibition of surface reactions, Absolute reaction rate theory of surface reactions.

Unit III — Lectures: 12

Comparison of homogeneous and heterogenous reactions, Study of equilibrium constant and steady state treatment for Arrhenius and Vant Hoff's complexes, Influence of substituents on reaction rates (inductive and electromeric effects), Linear free energy relationship, Taft equation, compensation effect, Hammett acidity functions.

Unit IV — Lectures: 10

Kinetic of initiation retardation, chain polymerization and ionic polymerization (anionic and cationic), Copolymerisation (with special reference to monomer reactivites ratios).

Unit V — Lectures: 08

Coordination polymerization, Degradation of polymers (oxidative, chemical and photolytic), an introduction to conducting polymers, Polyelectrolytes.

Teaching Learning Process

White board and marker teaching, activating prior knowledge through quiz design, Real life example to lifelong learning, Class interactions and discussions will be the part of teaching learning process.

Assessment Method

Internal assessment will be through assignments, presentation and class test. End semester examination will be for theory.

Essential Learning Material –

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *J.M. Hollas, Modern Spectroscopy, 4th edition (2004), John Wiley and Sons, Chichester.*
2. *C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.*
3. *E.M. Mc Cash, Surface Chemistry, Oxford University Press, Oxford (2001).*
4. *A.K. Cheetham and P Day, Solid State Chemistry Techniques, Oxford Univ. Press, Oxford (1988).*
5. *Joseph R. Lakowicz, Fluorescence Spectroscopy, 2nd edition, Plenum Press, New York. (1999).*

ELECTIVE PAPERS - IV

Paper - IV

Cheminformatics (CHE-404)

Total Lectures – 54 Credits: 3

Course Objective: The aim of the course is to impart knowledge about the role of computer technology in chemistry and library preparation.

Course Outcome- At the end of course student is expected to understand

- ❖ Introduction to cheminformatics.
- ❖ Role of computer in chemical research.
- ❖ Reaction database.
- ❖ Prediction of properties of compound.
- ❖ Combinatorial chemistry and library design

Unit I **Lectures: 08**

Introduction to cheminformatics, History and evolution of cheminformatics, use of cheminformatics, prospects of cheminformatics, molecular modeling and structure elucidation.

Unit II **Lectures: 12**

Role of computers in chemical research, introduction to cheminformatics, representation and manipulation of 2D and 3D molecular structures, chemical databases- design, storage and retrieval methods.

Unit III **Lectures: 12**

Reaction databases, representation of chemical reactions, search techniques (Full, Sub and Super structure), similarity searches, modelling of small molecules.

Unit IV **Lectures: 11**

Prediction of properties of compounds, linear free energy relations, quantitative ,structure-property relations, descriptor analysis; model building, modeling toxicity, structure-spectra correlations, prediction of NMR, IR and Mass spectra.

Unit V **Lectures: 11**

Combinatorial chemistry and library design –Introduction, data visualization, data mining methods, prediction of ADMET properties, cheminformatics tools for drug discovery.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links

- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *An Introduction to Chemoinformatics, Andrew R. Leach, V.J. Gillet, Springer.*
2. *Chemoinformatics: A Textbook, Johann Gasteiger, Thomas Engel, Wiley-VCH.*
3. *Chemoinformatics: Theory, Practice, & Products, Barry A. Bunin, Brian Siesel, Guillermo Morales, Jürgen Bajorath, Springer.*

Functional Organic Materials (CHE-405)
Total Lectures – 54 Credits: 3

Course Objective: Aim to provide knowledge on organic material used for electronic, photonic, energy, molecular machines etc.

Course Outcome- At the end of course student is expected to understand

- ❖ Organic electronic materials.
- ❖ Organic photonic materials.
- ❖ Organic energy materials.
- ❖ Organic molecular machines.
- ❖ Miscellaneous materials

Unit I **Lectures:10**

Organic Electronic Materials: Basic theory and design of molecular wires, resistors, diodes, transistors/OFETs, and OLEDs - Introduction to various device configurations and working principles

Unit II **Lectures:12**

Organic Photonic Materials: Basic theory and design of molecules for organic solar cells various approaches and introduction to some device aspects – molecules for NLO and imaging – molecular switches, motors and memories – Chirooptical materials and Photorefractive materials

Unit III **Lectures: 10**

Organic Energy Materials: Basic theory and design of organic flow batteries for energy storage applications – High energy materials – Covalent organic frameworks.

Unit IV **Lectures:10**

Organic Molecular Machines: Types – Design, synthesis, and function – examples.

Unit V **Lectures:12**

Miscellaneous Materials: Basic theory and design of materials for Organogels, organic

sensors and logic gates, organic magnets, organic superconductors, organic thermoelectrics.

Teaching Learning Process

White board and marker teaching, activating prior knowledge through quiz design, Class interactions and discussions will be the part of teaching learning process.

Assessment Method

Internal assessment will be through assignments, presentation and class test. End semester examination will be for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Functional Organic Materials by T. J. J. Müller and U. H. F. Bunz, Wiley-VCH, 2007*
2. *Introduction to Organic Electronic and Optoelectronic Materials and Devices by Sam-Shajing Sun, Larry R. Dalton, CRC Press, 2008*
3. *Organic Electronics Materials and Devices by S. Ogawa, Springer, 2015*
4. *Electronic Processes in Organic Semiconductors: An Introduction by A. Kohler and H. Bassler, Wiley-VCH, 2015*
5. *Organic Optoelectronics by Wenping Hu, John Wiley and Sons, 2013*
6. *Molecular Machines by T. Ross Kelly, Topics in Current Chemistry (Springer), 262, 2005*
7. *A Journey Through the World of Molecular Machines by C. Davis, Create Space, 2010*
8. *Molecular Machines and Motors: Recent Advances and Perspectives by A. Credi.*
9. *S. Silvi and M. Venturi, Topics in Current Chemistry (Springer), 354, 2014*
10. *Redox-Flow Batteries: From Metals to Organic Redox-Active Materials by J. Winsberg et al. Angew. Chem. Int. Ed. 2017, 56, 686-711.*

Analytical Electrochemistry (CHE-406)
Total Lectures – 54 Credits: 3

Course Objective: To impart fundamental knowledge on electrochemistry, its techniques, electromaterials, sensors and energy system.

Course Outcome- At the end of course student is expected to understand

- ❖ Introduction to analytical electrochemistry.
- ❖ Various types of electrodes.

- Techniques of electrochemistry.
- Electrochemical materials and sensors.
- Electrochemical energy system

Unit I **Lectures:10**

Mass transport, linear diffusion, Fick's laws and diffusion coefficient, the charged interface, potential step and potential sweep experiments, reactions controlled by rate of electron transfer and activated complex theory.

Unit II **Lectures:12**

Carbon electrodes, semiconductor film electrodes, microelectrodes, ultra-micro electrodes, ion-selective electrodes, porous electrodes and non-uniform reaction rates, hydrodynamic/rotating disk electrodes, semiconductor electrodes and electrical capacitance. Cyclic voltammetry in reversible, quasi-reversible and irreversible systems, study of reaction mechanisms, surface modification in charge transfer and interfacial activity electron transfer in DNA and biosystems.

Unit III **Lectures:08**

Impedance spectroscopy, Scanning Electrochemical Microscopy, Electrochemical AFM and STM, Electrochemical Quartz Crystal Microbalance

Unit IV **Lectures:12**

Electrochemical Materials and Sensors: Electroactive Fullerenes, carbon nanotubes, biomolecules, controlled potential techniques, electrochemical synthesis of nanomaterials, nanowires and conducting polymers, functional nanoparticles as catalysts and sensors, MOSFETS and ISFETS, solid state molecular devices.

Unit V **Lectures: 12**

Electrochemical Energy Systems: Photo-electrochemistry, monitoring photolytic intermediates, Electroluminescence and devices and sensors, Electro - chemiluminescence, digital simulation of electrochemical problems, fuel cells: electrode materials, diagnostic tools in fuel cell research, determination of injection efficiency and electron diffusion length under steady state condition, small-amplitude time-resolved methods, organic solar cells.

Teaching Learning Process

White board and marker teaching, activating prior knowledge through quiz design, Class interactions and discussions will be the part of teaching learning process.

Assessment Method

Internal assessment will be through assignments, presentation and class test. End semester examination will be for theory.

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd edition 2001, John Wiley & Sons*
2. *Allen J. Bard (Ed), Electroanalytical Chemistry, Vol.13, Plenum Press 1983*
3. *Joseph Wang, Analytical Electrochemistry, 3rd edition 2006, John Wiley & Sons*
4. *Paola Ceroni, Alberto Credi and Margherita Venturi (Ed), Electrochemistry of Functional Supramolecular Systems, 2010, John Wiley & Sons*
5. *Kosuke Isutzu, Electrochemistry in Non-aqueous Solutions, Wiley – VCH Verlag GmbH & Co. 2002*
6. *K. Kalyanasundaram (Ed), Dye-Sensitized Solar Cells, EPFL Press, 1st Edition 2010(ISBN 978-2-940222-36-0)*
7. *J. Newman, Electrochemical Systems, Wiley-Interscience, 3rd edition 2004*

UNIVERSITY ELECTIVE – IV

Paper - VI

Nanochemistry (CHE-408)

Total Lectures – 54 Credits: 3

Course Objective: To aware the student about nanoscale materials, their preparation, experimental techniques, applications and environmental issues.

Course Outcome- At the end of course student is expected to understand

- ❖ History, scope and perspectives of nanochemistry
- ❖ Experimental techniques in nanochemistry
- ❖ Size effects in nanochemistry
- ❖ Applications of Nanoparticle in various field
- ❖ Environmental issue of nanoparticles

Unit I **Lectures: 12**

Introduction- History scope and perspectives of nanochemistry. Synthesis and Stabilization of Nanoparticles, Chemical Reduction; Reactions in Micelles, Emulsions, and Dendrimers; Photochemical and Radiation Chemical Reduction.

Unit II **Lectures: 12**

Experimental Techniques- Transmission and scanning electron microscopy, Probe Microscopy, X-ray diffraction, Neutron diffraction, Miscellaneous Techniques,

Comparison of Spectral Techniques used for Elemental Analysis.

Unit III **Lectures: 12**

Size Effects in Nanochemistry- Models of Reactions of Metal Atoms in Matrices; Properties; Kinetic Peculiarities of Chemical Processes on the surface of Nanoparticles; Thermodynamic Features of Nanoparticles.

Unit IV **Lectures:08**

Applications of nanoparticle in various fundamental research, industries, medical field.

Unit V **Lectures:10**

Environmental issue; toxicity, biosafety and ethical issue in applications of nanoparticle.

Teaching Learning Process

- White board and marker teaching
- Activating prior knowledge by Random questioning.
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods

- In text question,
- Poster presentation/Oral test
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester university theory Examination

Essential Learning Material

- Text Books
- Class notes
- Video links
- Digital library links
- NGB e-library

Books Suggested *(Names of Publishers may vary as per copyright status):*

1. *Nanomaterials and Nanochemistry, edited by C. Brechignac, P. Houdy, M. Lahmani, Springer- Verlag, Berlin.*
2. *Nanoparticle Technology Handbook. M. Hosokawa, K. Nogi, M. Naito, T.Yokoyama (Eds.), Elsevier.*
3. *Nanotechnology Basic Calculations for Engineers and Scientists, Louis Theodore, John Wiley and Sons.*
4. *Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A Ozin, André Arsenault, Ludovico Cademartiri, RSC Public.*