JAMIA HAMDARD

(Deemed to be University)

HAMDARD NAGAR, NEW DELHI

Master of Science Chemistry

TWO YEARS FULL-TIME PROGRAMME

RULE, REGULATIONS AND COURSE CONTENTS

Programme code: 510

Department of Chemistry

SCHOOL OF CHEMICAL AND LIFE SCIENCES

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Department of Chemistry

http://jamiahamdard.edu/Department/Deptindex.aspx?page=a&ItemID=ic&nDeptID=gm

The objective of any programme at Jamia Hamdard is to prepare their students for society at large. Jamia Hamdard envisages all the programmes of study in the best interest of their students and in this endeavour. Jamia Hamdard has adopted Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes. The LOCF approach provides a focused, outcome-based curriculum at the undergraduate level with an aim to structure the teaching-learning experiences in a more student-centric manner.

The Department of Chemistry is well known for its excellence in teaching and research. The faculty members of the department are engaged in state-of-the-art research as well as guiding the Ph.D., M. Sc. and Post Doctoral Students. The mission of the Department is to provide knowledge in Chemistry that offers opportunities for high quality and comprehensive learning experience for students. The Department offers an M.Sc. programme in Chemistry with the option of specialization in Organic Chemistry in addition to B.Sc. (Hons.) programme and these courses are taught semester wise. The students are assigned intensive project assignments on topics of current research interest and are exposed to sophisticated instrumental techniques in their budding stage itself. Advanced level optional courses are also offered at the Ph.D. levels. Collaborative research programmes with many research laboratories and research institutes in Delhi and outside India are also operating very successfully with mutual benefit. The Department has distinguished itself as a centre for innovative and pioneering research in a wide range of areas in chemistry and chemistry interfacing with physical and biological sciences. Department has funding from the Department of Science and Technology, the Department of Biotechnology (DBT), Defence Research & Development Organisation (DRDO) and the University Grant Commission (UGC). The University is also funding the faculty through Research Promotion Grants for beginners.

The curriculum of the postgraduate program is an outcome of our continued, collective and collaborative effort with a vision to develop an innovative, responsive, inclusive, flexible, and dynamic curriculum in tune with the global educational needs for the 21st century and the National education policy 2020. Our curricular structure, courses, pedagogy and assessment have catered to the development of diversified, integrated, interdisciplinary knowledge and skills as well as the inculcation of the values to survive in the highly competitive knowledge and skilled society.

1. Vision and Mission of the Department

Department aspires to attain global recognition in chemistry education, research, and training for meeting the growing needs of industry and society.

The mission of the Department includes:

M1. To make the department a growing center of excellence in teaching, cutting-edge research, curriculum development and popularizing Chemistry.

M2. To impart education through a well-defined curriculum driven by the needs of the students, the mission of the institution and the program, the standards of the discipline, and the needs of the partners.

M3. To provide state of art research facilities to generate new knowledge and develop new technologies in the thrust areas of chemistry.

M4. To develop linkages and collaborations in order to strengthen industry-academia relations for mutual benefit and address problems of societal importance

M5. To outreach in the form of books, online courses, and other Chemistry education activities that showcase the role of Chemistry as a central science.

Structure of the Program

The curriculum is designed to provide a cohesive, intense and productive educational experience in diverse interdisciplinary domains. Program structure consists of foundational and advanced levels topics in chemistry and from other sciences with an emphasis to develop research aptitude.

2. **Duration of the course:** The curriculum of Two-year M.Sc. Chemistry is spread over four semesters designated as under:

1^{st} Semester – July-Nov of 1^{st} year
2^{nd} Semester – Dec-April of 1^{st} year
3^{rd} Semester – July-Nov of 2^{nd} year
4^{th} Semester – Dec-April of 2^{nd} year

Teaching days in each semester shall be not less than **90 days**.

3. **Medium of instruction and examination:** **English**

4. **Eligibility for admission:** A candidate seeking admission to the M.Sc. program must have passed B.Sc. or equivalent examination from a recognized university under 10+2+3 system with Chemistry as one of the subjects and secured at least 45% marks or equivalent CGPA in the aggregate.

5. **Qualification Descriptors (QDs):**

QD1. Development of the appreciation of the uses of chemistry in daily life and awareness of the role of chemistry in contemporary societal and global issues, including areas such as sustainability and green chemistry.

QD2. To demonstrate comprehensive knowledge of broad concepts, principles and theories of chemistry as well as advanced and emerging topics that stress scientific reasoning and analytical problem-solving perspective.

QD3. Development of competence in intellectual, practical and transferable skills (communication skills, IT skills, Interpersonal skills) necessary for a chemist

QD4. Demonstration of an ability to apply underlying concepts and principles outside the context in which they were first studied in interdisciplinary scenarios.

6. **Mapping of Qualification descriptors (QDS) with Mission Statements (MS)**

*3:

	MS1	MS2	MS3	MS4	MS5
QD1	**3**	**3**	**3**	**3**	**3**
QD2	**3**	**3**	**3**	**3**	**3**
QD3	**3**	**3**	**3**	**3**	**3**
QD4	**3**	**3**	**3**	**3**	**3**

High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

7. Programme Learning Outcomes (PLOs):

PLO1. To acquire comprehensive knowledge of concepts, principles and theories of chemistry as well as advanced and emerging topics that stress scientific reasoning and analytical problem-solving perspective.

PLO2. Competence in understanding intellectual, practical and transferable skills (communication skills, IT skills, Interpersonal skills) necessary for a chemist

PLO3. Demonstration of an ability to apply underlying concepts and principles outside the context in which they were first studied in interdisciplinary scenarios.

PLO4. Acquisition of competence in the operation of standard chemical instrumentation and techniques, for conducting the documented laboratory procedures and other practices of chemistry.

PLO5. Apply skills for gathering, evaluation, analysis and presentation of information, ideas, concepts and quantitative and/or qualitative data.

PLO6. Evaluate the impact of chemical processes and materials in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.

PLO7. Design and develop small projects for applications in science and technology, that meet specified needs with appropriate significance for public health and safety, cultural, societal and environmental considerations

8. Programme Specific Outcomes (PSOs):

The M. Sc program in Chemistry is designed to develop in students an in-depth knowledge of the core concepts and principles that are central to the understanding of this core science discipline.

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

PSO 1. Have a familiarity with the theoretical knowledge and understanding of the fundamental concepts, principles and processes in main branches of chemistry, namely, organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry and biochemistry.

PSO 2. Understand the background of organic reaction mechanisms, complex chemical structures, and instrumental methods of chemical analysis, molecular rearrangements and separation techniques.

PSO 3. Develop quantitative and qualitative practical skills through hands-on training in handling basic chemical laboratory instruments.

PSO 4. Able to synthesize, separate, purify and characterize compounds using laboratory and instrumentation techniques.

PSO 5. Carry out experiments in the area of organic analysis, estimation, separation, derivative process, inorganic semi microanalysis, preparation, conductometric and potentiometric analysis.

PSO 6. Analyze the data obtained from sophisticated instruments (like FTIR, NMR, GCMS, HPLC, GCMS UV-Vis, Fluorescence, and TGA) for structure determination and chemical analysis.

PSO 7. Work in the interdisciplinary and multidisciplinary areas of sciences

PSO 8. Apply green/sustainable chemistry approach towards planning and doing experiments and understanding the causes of environmental pollution and methods of pollution control.

PSO 9. Design and develop small projects for applications in science and technology, that meet specified needs with appropriate significance for public health and safety, cultural, societal and environmental considerations

9. Mapping of PLOs and PSOS with QDs

	QD1	QD2	QD3	QD4
PLO1.	**3**	**3**	**2**	**2**
PLO2.	**2**	**3**	**3**	**2**
PLO3.	**2**	**3**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**
PLO5.	**2**	**2**	**3**	**3**
PLO6.	**3**	**2**	**2**	**3**
PLO7.	**3**	**2**	**2**	**3**
PSO1	**3**	**3**	**2**	**2**
PSO2	**2**	**3**	**3**	**2**
PSO3	**2**	**3**	**3**	**2**
PSO4	**2**	**2**	**2**	**3**
PSO5	**2**	**2**	**3**	**3**
PSO6	**2**	**2**	**3**	**3**
PSO7	**2**	**2**	**3**	**3**
PSO8	**3**	**3**	**3**	**3**
PSO9	**3**	**2**	**3**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

10. Overview of M.Sc. Chemistry Curriculum

Total No. of Semesters: 04 **Total No of credits: 92**

S. No.	Course type	Type	No.	Credits
1.	Core courses	Theory	14	42
		Laboratory	07	28
		Project	01	10
2.	Discipline centric elective Courses (DCE)		02	06
3.	Generic elective Courses [Option is available for credit transfer from MOOC s/SWAYAM platforms		02	06

The program offers the right proportion of a combination of theory and laboratory-based courses. Organization of course content and pedagogy are aimed at developing a comprehensive knowledge in chemistry beyond the boundaries of chemistry sub-domains like organic, inorganic, etc., and facilitate the students to navigate smoothly towards advanced level courses in any organic chemistry or related interdisciplinary or cross-discipline domains. Theory courses are offered at two levels spread over four semesters. Classroom attendance, interaction with peers, and faculty, problem-solving approach, and integration wian th online learning management system are features of the program. This two-year M.Sc. Chemistry program covers the foundation and advanced courses with a special focus on pure chemistry such as Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Biochemistry, Physical Chemistry, Computational Chemistry, Identification and Analysis of Organic compounds, Spectroscopy of Organic Compounds and Synthesis of Organic Compounds. Practical Training through seminar and workshop participation, projects, are also involved. Courses offered in the first two semesters aim at laying a strong foundation in professional chemistry education. These courses are aimed at developing in-depth knowledge in specialized areas of organic chemistry and creating awareness about relevance and contemporary trends in research in those areas. Separate laboratory course credits are designed to equip the students with skills enabling them to enter a research-oriented career or industry or academic arena, after completing the program. In addition to developing experimental skills in chemistry, principles, and tools of practicing eco-friendly chemistry, organizing, maintaining a chemistry laboratory, laboratory safety, micro-scale experiments, students develop hands-on experience with modern instruments and receive tutorial instructions from research scholars, post-doctorate researchers, and visiting experts. Laboratory courses also inculcate ethics, values and competence in communication. Components such as summer internship, seminar participation, project and comprehensive viva are opportunities offered to students to get wide-ranging experience in research and develop much-needed career skills. Moreover, the proposed curriculum has the flexibility to include new programs with specialization in chemistry or programs of inter/cross-disciplinary nature. The rules and regulations of the Choice Based Credit System (CBCS) are applicable to this program.

The courses offered under this Programme of Study are designated as Core courses and Elective courses.

A course designated as Core course must be completed by students to receive the degree in this Programme.

Elective courses can be chosen from:

a) A list of elective courses (Advanced Chemistry) prescribed by the Department of chemistry designated as Discipline centric electives (DCE).

b) Any course offered by any Centre/Department/School of Jamia Hamdard under CBCS as a generic elective. The option is also available for credit transfer from MOOCs/SWAYAM platforms.

For courses offered from MOOCs/SWAYAM platforms, a student will be permitted to pursue online audit courses up to a maximum of 06 credits. However, during one semester a student will not be permitted to transfer more than 03 credits of online courses. Though the host institute may award more credits to an online course, the maximum number of credits assigned to an online course shall not exceed 3 credits, and the minimum shall be 2 credits. SWAYAM Counsellor of the department shall facilitate online courses through the SWAYAM platforms and shall obtain marks from the host institution.

All the above courses of the M.Sc. Chemistry program will be audit courses, i.e., for all the papers including elective courses and the courses completed through MOOCs/SWAYAM platforms, credits earned will be taken into consideration for the calculation of CGPA and declaration of results.

Additional Credit courses: (Non-audit courses or Credits under Non-CGPA)

Interested candidates may enroll in various co extracurricular activities. At least 02 credits each will be given in an activity for one year. An option is also available for credit transfers from MOOCs/SWAYAM platforms. Additional credits will be shown in the transcripts of the student

11. Semester-wise scheme of M.Sc (Hons.) Chemistry Program as proposed for Jamia Hamdard:

I SEMESTER								
Paper Code	**Title of the Paper**	**Paper Category**	**Semester Exam**	**Internal Assessment**	**Total Marks**	**Hours per week**		**Course Credit**
						L	**P**	
MCHCC - 101	Physical Chemistry - I	Core	75	25	100	03	00	03
MCHCC - 102	Organic Chemistry - I	Core	75	25	100	03	00	03
MCHCC-103	Inorganic Chemistry - I	Core	75	25	100	03	00	03
MCHCC-104	Analytical Chemistry	Core	75	25	100	03	00	03
MCHCC-105	Lab. Course in Physical Chemistry- I	Core	75	25	100	00	06	03
MCHCC-106	Lab. Course in Inorganic Chemistry - I	Core	75	25	100	00	06	03
MCHCC-107	Lab. Course in Organic Chemistry-I	Core	75	25	100	00	06	03
Total: I Semester			**525**	**175**	**700**	**12**	**18**	**21**
II SEMESTER								
Paper Code	**Title of the Paper**	**Paper Category**	**Semester Exam**	**Internal Assessment**	**Total Marks**	**Hours per week**		**Course Credit**
						L	**P**	
MCHCC - 201	Physical Chemistry - II	Core	75	25	100	03	00	03
MCHCC - 202	Organic Chemistry - II	Core	75	25	100	03	00	03
MCHCC - 203	Inorganic Chemistry - II	Core	75	25	100	03	00	03
MCHCC - 204	Applications of Spectroscopy	Core	75	25	100	03	00	03
MCHCC-205	Lab. Course in Physical Chemistry- II	Core	75	25	100	00	06	03
MCHCC-206	Lab. Course in Inorganic Chemistry - II	Core	75	25	100	00	06	03
MCHCC-207	Lab. Course in Organic Chemistry-II	Core	75	25	100	00	06	03
Total: II Semester			**525**	**175**	**700**	**12**	**18**	**21**
Total: I Semester and II Semester			**1050**	**350**	**1400**			**42**

III SEMESTER								
Paper Code	**Title of the Paper**	**Paper Category**	**Semester Exam**	**Internal Assessment**	**Total Marks**	**Hours per week**		**Course Credit**
						L	**P**	
MCHCCO - 301	Chemistry of Natural Products - I	Core	75	25	100	03	00	03
MCHCCO-302	Organic Synthesis – I	Core	75	25	100	03	00	03
MCHCCO - 303	Photochemistry and Pericyclic reactions	Core	75	25	100	03	00	03
MCHDCE-304/305/306	Discipline Centric Elective – I	DCE	75	25	100	03	00	03
MCHOE- I course code of the elective chosen	Generic elective Course	Generic elective	75	25	100	03		03
MCHC-309	Lab. Course	Core	150	50	200	00	20	10
Total: III Semester			**525**	**175**	**700**	**15**	**20**	**25**
IV SEMESTER								
Paper Code	**Title of the Paper**	**Paper Category**	**Semester Exam**	**Internal Assessment**	**Total Marks**	**Hours per week**		**Course Credit**
						L	**P**	
MCHCCO - 401	Chemistry of Natural Products - II	Core	75	25	100	03	00	03
MCHCCO - 402	Organic Synthesis – II	Core	75	25	100	03	00	03
MCHCCO-403	Heterocyclic Chemistry	Core	75	25	100	03	00	03
MCHDCE-404/405/406	Discipline Centric Elective - II	DCE	75	25	100	03	00	03
MCHOE-II course code of the elective chosen	Generic elective Course	Generic elective	75	25	100	03	00	03
MCHCC-409	Project	Project	150	50	200	00	20	10
Total: IV Semester			**525**	**175**	**700**	**15**	**20**	**25**
Total: III & IV Semester			**1050**	**350**	**1400**			**50**
Grand Total: Sem I - IV					**2800**			**92**

12. List of DCE courses:

Paper Code	Paper Title	Paper Code	Paper Title
MCHDCE-304	Medicinal Chemistry	MCHDCE-404	Polymer Chemistry
MCHDCE-305	Catalysis and Green Chemistry	MCHDCE-405	Bioorganic and Bioinorganic Chemistry
MCHDCE-306	Advanced methods of chemical analysis	MCHDCE-406	Molecular Modelling &Drug Design

- Student is required to opt for one Discipline centric elective course of 03 credits each in semester III and Semester IV.
- Student is required to opt for elective courses of minimum 03 credits each in semester III and Semester IV, from any discipline/subject of his or her choice offered in any department of the university with an option available for credit transfer from MOOCs/SWAYAM platforms.
- The Course codes of the generic elective Courses will be designated by adding Suffixes to MCHOE-I and MCHOE-II.

13. List of generic elective Courses offered by the Department of Chemistry include

Paper Code			
MCHOE-I		MCHOE-II	
Paper Code Suffix	Paper Title	Paper Code Suffix	Paper Title
307	Environmental Chemistry	407	Chemistry in Nanoscience
308	Food Chemistry-I	408	Food Chemistry-II

14. Attendance:

a) All the students must attend every lecture and practical class. However, to account for unforeseen contingencies, the attendance requirement for appearing in the semester examinations shall be a minimum of 75% of the classes prescribed for each course.

b) In order to maintain the attendance record of a particular course, a roll call will be taken by the teacher in every scheduled lecture and practical class. For the purpose of attendance, each practical class will be counted as one attendance unit, irrespective of the number of contact hours. Attendance on account of participation in the prescribed and notified activities such as, NCC, NSS, Inter-University sports, educational tours/fieldwork, shall be granted provided the participation of the student is duly verified by the officer-in-charge and is sent to the Head of the Department within two weeks of the function/activity, etc.

c) The teacher shall consolidate the attendance record for the lectures and practicals at the end of each month and submit it to the Head of the Department. At the end of the semester, the teacher shall consolidate the attendance record for the whole semester and submit it to the Head of the Department. The statement of attendance of students shall be displayed by the Head of the Department on the Notice Board. A copy of the same shall be preserved as a record. Attendance records displayed on the Notice Board shall be deemed to be a proper notification for the students and no individual notice shall be sent to any student.

d) If a student is found to be continuously absent from the classes without any information for a period of 30 days, the concerned teacher shall report the matter to the Head of the Department who will report the matter to the Registrar through the Dean of the school for appropriate action that will include striking off the name of such student(s) from the rolls. Such a student shall not be eligible for re-admission after the prescribed period of 7 days. The re-admission shall be affected only after the payment of the prescribed re-admission fee.

e) A student with less than 75% attendance in a course in a semester shall be detained from appearing in the semester examination of that course. The Dean of the School may consider the application for condoning up to 5% of attendance on account of sickness, provided the medical certificate, duly certified by a Registered Medical Practitioner/Public Hospital had been submitted in the office of the Head of the Department at the time of rejoining the classes immediately after the recovery from illness. The HoD shall forward such cases along with all related documents to the Dean. The cases of students with less than 70% attendance may be forwarded to the Vice-Chancellor through Dean for considering these cases to further condone the attendance as a special case.

f) A student detained on account of a shortage of attendance in any semester shall be re-admitted to the same class in the subsequent academic year on payment of prescribed fees applicable in that year to complete the attendance requirement of that course.

15. Internal Assessment:

The Internal Assessment marks will constitute up to 25% of the total marks allotted to a course. For awarding Internal Assessment marks, there shall be three Sessional tests of 25 marks each for each course in a semester and average of the best of two will be taken as final marks scored. The first sessional test shall be taken in the beginning of the session, 2nd after two months of the session, and the 3rd sessional test 15 days before the commencement of the final semester examination.

For the evaluation of lab work, laboratory notebooks, practical viva-voce shall be taken into account. The marks shall be awarded by the respective teachers conducting the practical course. For sessionals and during the examination, no department shall permit discontinuance of classes. Under compelling circumstances such as sickness of the student or mounting in the family, the candidate may be given another chance. For sickness, only a credible medical certificate issued by a hospital shall be considered. In case of causalities, a letter from the parents would be required.

7. Semester Examinations:

There shall be not less than two theory courses and one lab course in each semester, except 4th Semester. The detailed contents of the courses of studies shall be prescribed by respective Board of Studies and shall be reviewed regularly.

A student who fails in theory papers of end semester examination may be given a chance to appear in 3 papers in Makeup examination to clear those papers. In no case shall it be allowed to the students who abstain from appearing in the semester examination. Students who are detained due to shortage of attendance shall not be allowed to appear in the Makeup examination.

Semester examination shall be held at the end of each semester as per schedule given in the Academic Calendar of the School.

Upto maximum of seven days preparatory holidays may be given to the examinees before the start of the semester examinations.

The question paper for semester examinations, shall be set either by the external examiner or an internal examiner. The Board of Studies of a department shall draw a panel of name of examiner, both internal and external, for approval by the Vice chancellor. **If the external examiner is unable to send the question paper by the deadline set by the examination branch of the University, the head of the Department after consultation with the examination branch shall get the paper set internally by a faculty.** The papers set by the examiners can be moderated in consultation with the teacher who taught that course. Teachers appointed on contractual basis with appointment of less than one academic session, and temporary as well as ad-hoc teachers may not ordinarily be appointed as examiners. All such teacher, however, will be expected to assist in the practical examination.

The question paper shall have five questions. There shall be one question from each of the 4 units of the course and one question shall contain objective type/short answer questions covering all the units of the course. The candidate shall have to answer all the five questions. There shall, however, be internal choice within a unit. The choice shall be given by setting alternative questions from the same unit. The question paper should be such that it covers all the topics of that course.

The durations of the semester examination of a theory course shall be Three hours. Practical exams of a lab course shall be of at least four hours duration. The practical examination shall be conducted by an external and an internal examiner and assisted by other teachers.

For projects, **each student shall submit three typed bound copies of his/her project work to the supervisor(s)** by the end of the 4th semester. A student shall not be entitled to submit the project report unless he/she has pursued project work during 4th semester under the guidance of a duly appointed supervisor(s). The report shall embody the candidates own work and an up-to-date review of the subject area. The write-up shall detail a critical assessment of the subject area and indicate in what respect the work appears to advance the knowledge of the subject concerned and future course of investigation required.

The project report shall be examined by a Board of Examiners and the student shall have to appear for viva-voce. The Board of Examiners shall consist of the following:

- An external examiner
- Head of the Department
- A senior teacher of the Department
- Concerned Supervisor(s)

The Board shall examine the project report of all the students, **conduct the viva-voce and award marks for the project and viva-voce. All other teachers of the department will also be invited by the Head of the Department to be present during the examination.** In case a student fails to secure the minimum pass marks, he/she may be asked to appear in the viva-voce again, or he/she may be asked to revise the project report in the light of the suggestions of the examiners and resubmit. For this, he/she will have to enroll as an ex-student in the next session. A resubmitted project report will be examined as above and viva voce shall be conducted along with other students.

Under the CBCS, the requirement for awarding a degree or diploma or certificate is prescribed in terms of number of credits to be completed by the students.

a) Credit Point: It is the product of grade point and number of credits for a course.

b) Credit: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

c) Cummulative Grade Point Average (CGPA): It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points

secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

d) Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale.

e) Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P, and F.

f) Programme: An educational programme leading to award of a Degree, diploma or certificate.

g) Semester Grade Point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

h) Semester: Each semester will consist of 15-18 weeks of academic work equivalent to not less than 90 actual teaching days. The odd semester may be scheduled from July to November and even semester from December to April.

i) Transcript or Grade Card or Certificate: Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

9. Semester System and Choice Based Credit System

The semester system accelerates the teaching-learning process and enables vertical and horizontal mobility in learning. The credit based semester system provides flexibility in designing curriculum and assigning credits system provides a 'Cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning.

11. Classification of Result:

a) The following grading system, with 10-point scale shall be followed to represent performance of students in the examination:

Grades and Grade Point:

Letter Grade	Grade Point	Marks
O (Outstanding)	10	90-100
A+ (Excellent)	9	80-89
A (Very Good)	8	70-79
B+ (Good)	7	60-69
B (Above Average)	6	50-59
C (Average)	5	45-49
P (Pass)	4	40-44
F (Fail)	0	Less than 40
AB (Absent)	0	

Earned Credits (EC):

The credits for the courses in which a student has obtained P (minimum passing grade for a course) or a higher grade in the semester exam shall be counted as credits earned by him/her. Any course in which a student has obtained 'F' or 'AB' grade shall not be counted towards his/her earned credits.

12. Computation of SGPA and CGPA:

Following procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

a) SGPA (Semester Grade Point Average) shall be awarded on successful completion of each semester.
b) CGPA (Cumulative Grade Point Average), which is the Grade Point Average for all the completed semesters at any point in time shall be awarded in each semester on successful completion of the current semester as well as of the previous semester. In 1st semester, CGPA is not applicable.

13. Calculation of SGPA and CGPA of A Student in a semester:

$$\text{SGPA} = \frac{\sum (\text{Earned Credits} \times \text{Grade Point})}{\sum (\text{Total Course Credits in a Semester})}$$

$$\text{CGPA} = \frac{\sum_{J=1}^{M} (\text{Earned Credits} \times \text{grade point})}{\sum (\text{Total Course Credit in a Semester})}$$

Where m is the number of semesters passed

14. Promotion:

a) Promotion from 1st semester to 2nd semester and from 3rd semester to 4th semester shall be automatic.

b) A student shall be promoted to the 3rd semester of the programme if he/she has passed in each theory and practical courses separately of 1st and 2nd semesters. Provided that a student may carry over a maximum of 8-9 credits (equivalent to two-three theory papers, which may be of 3 or 4 credits each) of courses uncleared, to the 3rd semester). A candidate will be given a total number of 2 attempts, inclusive of the first attempt, to clear the papers in which he/she fails. For such students, promotion to the next higher class will be considered subject to rules relating to passing the 1st and 2nd semester

examinations within two academic years. Award of degree shall be subject to successfully completing all the requirements of the programme of study within four years from admission. A student who fails in theory papers of end semester examination may be given a chance to appear in 3 papers in Make-up examination to clear those papers. In no case shall it be allowed to the students who abstain from appearing in the semester examination.

c) Candidates who are unable to appear in the examination because of serious illness at the time of examinations may be given another chance. The request has to be processed through the Head of the Department to the Vice Chancellor. The Vice chancellor may look into the merit of the case and decide accordingly.

15. Classification of Successful Candidates:

The result of successful candidates who fulfil the criteria for the award of M.Sc. shall be classified after the 4^{th} semester, on the basis of his/her CGPA of all the four semesters.

Classification shall be done on the basis of following criteria:

a) He/She will be awaded "1^{st} Division" if his/her final marks are greater than or equal to 60% in all the semester examinations in the first attempt. He/she will be awarded "1^{st} Division" if his/her final CGPA is 7 or above
b) He/She will be awarded "2^{nd} Division" if his/her final marks are greater than or equal to 50% but less than 60% in all the semester examinations in the first attempt. He/she will be awarded "2^{nd} Division" if his/her final CGPA is 6 pr above but less than 7
c) He/She will be awarded "Pass" if his/her final marks are greater than or equal to 40% but less than 50% in all the semester examinations in the first attempt. He/she will be awarded "Pass" if his/her final CGPA is 5 or above but less than 6.
d) He/she will be treated as "fail" if his/her final marks are less than 40% in all the semester examinations in the first attempt. He/she will be treated as "fail" if his/her final CGPA is less than 5.

16. Span Period:

a) 1^{st} and 2^{nd} Semester Exams: Within two years from the first admission to the programme
b) All requirement of M.Sc. degree within a total period of four years from the date of their first admission.

17. Improvement:

A candidate who wishes to improve the previous performance will be allowed to do so as per the following regulation:

a) A student shall be allowed only once to reappear in the semester examination of up to four theory courses along with regular students of that semester to improve upon the

previous performance. The examination fee charge from such candidates shall be double the current examination fee.

b) Such a student shall inform the Head of the Department in writing of his/her intention to improve the performance two months before the date of the semester examination is to be held. Only the candidates who have attained at least C grade shall be eligible for improvement in performance.
c) If the student improves the performance, he/she shall be required to submit the earlier mark-sheet/degree. A new mark-sheet and degree shall be issued. The new mark-sheet/degree shall bear the year in which the student improved the grade.
d) In case the grade obtained in improvement is lower than the one obtained earlier; the higher grade shall be retained.

18. Consolidated Mark sheet:

On successful completion of the course, a consolidated mark sheet consisting of marks of all the Semesters shall be issued to the students by the Examination Section.

Semester - I
Scheme of courses

SEMESTER I
PAPER CODE: MCHCC-101 **PAPER TITLE: PHYSICAL CHEMISTRY-I**
Total Credits: 3 Total Lectures: 50

Objectives: The course deals with physical chemistry in a broad perspective. Emphasis is given to the most important quantum mechanical aspect of model systems, such as particles in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom. The concepts of laws of thermodynamics, free energy, chemical potential and entropies, partial molar properties etc. will be discussed. Electrochemistry applied to energy, catalysis and biological systems-influence of various parameters will be presented. Various adsorption isotherms and estimation of the surface area is also presented.

Course Learning Objectives:

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

CLO1. Have a theoretical understanding of the concepts of laws of thermodynamics, free energy, chemical potential and entropies, partial molar properties, and their importance in chemistry (Remember and understand).
CLO2. The student will get familiar with partial molar properties and other thermodynamic parameters (Remember and understand).
CLO3. Understand the various adsorption isotherms methods (Understand).
CLO4. Application of such methods for estimation of the surface area of adsorption surface in laboratory and day to day life (Analyze and apply).
CLO5. Apply the understanding of electrochemistry and its application to energy catalysis and biological systems and the influence of various parameters on it while carrying out related chemical transformations in the laboratory.

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	**3**	**3**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**
PSO1	**3**	**3**	**2**	**2**	**2**
PSO2	**3**	**3**	**2**	**2**	**2**
PSO3	**3**	**3**	**3**	**2**	**2**
PSO4	**2**	**2**	**2**	**3**	**3**
PSO5	**2**	**2**	**3**	**3**	**2**
PSO6	**2**	**2**	**2**	**3**	**3**
PSO7	**2**	**2**	**2**	**3**	**3**
PSO8	**2**	**2**	**2**	**2**	**3**
PSO9	**2**	**2**	**2**	**2**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit – I **[12Hours]**

Thermodynamics: Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties, partial molar free energy, partial molar volume, partial molar heat content and their significance. Determination of these quantities. Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions, activity, activity coefficient, Debye-Hockel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients.

Application of phase rule of three-component systems; second-order phase transitions.

Unit – II **[15 Hours]**

Electrochemistry of solutions: Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum mode. Thermodynamics of electrified interface equations. Derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces. Guoy-Chapman, Stern, Graham-Devanathan-Mottwatts, Tobin, Bockris, Devanathan models.

Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot. Semiconductor interfaces- theory of double layer at semiconductor, electrolyte solution interfaces.

Applications of electrochemistry in energy, e.g., Hydrogen cell, Li-battery, solar cell, fuel cells. Electrocatalysis-influence of various parameters, Hydrogen electrode.

Bioelectrochemistry, threshold membrane phenomena, Nernst-Planck equation, Hodges-Huxley equations, core conductor models, electrocardiography, electrodialysis. Polarography theory, llkovic equation; half-wave potential and its significance.

Unit – III **[13 Hours]**

Quantum mechanics: The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particles in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom, Hamiltonian Operator, Position Operator, Linear momentum and Angular momentum Operator, Commutation of an operator, Commutation of angular momentum and position (Heisenberg principle), Eigen Value and Eigen Functions, Normalization and orthogonality of Ψ. Determination of position and momentum of a particle in a one-dimensional box from Ψ expression.

Unit – IV **[10 Hours]**

Adsorption: Surface tension, capillary action, the pressure difference across a curved surface (Laplace equation), vapor pressure of droplets (Kelvin equation), Gibbs and Langmuir adsorption isotherms, estimation of surface area (BET equation), surface films on liquids (electro-kinetic phenomenon), catalytic activity of surfaces. Catalysis- Concept of traditional catalysts and nanocatalysts and their application in industry.

Suggested reading

1. Physical Chemistry, P.W.E. Atkins, ELBS, Introduction Quantum Chemistry, A.K. Chandra, Tata Mc Graw Hill.
2. Quantum Chemistry, I. N. Levine, Prentice Hall.
3. Coulson,s valence, R. McWeeny, ELBS
4. Thermodynamics, J. Rajaram; J.C. Kuriacose, Educational Publishers.
5. Physical Chemistry of surfaces, A.W. Adamson, John Wiley and Sons.
6. Quantum Chemistry, E. Walter, Kinball publications
7. Statistical Physics (Part I) (Course of Theoretical Physis Vol. 5), L.D. London; E.M. Lefshitz, Perganion press.
8. Modern Electrochemistry Vol I and Vol II, J.O.M. Bockris; A.K.N. Reddy, Plenum publication Electrochemistry by Bokris.

9. Quantum Chemistry by McQuiry.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of students' learning.
  - Class Tests, Worksheets.
  - Assignments, and projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of students' learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Electrochemistry, Thermodynamics, Quantum mechanics, Adsorption, Eigen Value, Eigen Functions.

SEMESTER I
PAPER CODE: MCHCC-102 **PAPER TITLE: ORGANIC CHEMISTRY-I**
Total Credits: 3 Total Lectures: 50

Objective

The core course Organic Chemistry-I is designed to encompass the basic to elaborated understanding of stability and reactivity of organic molecules. The role of various factors on the fate of the reactions. The course is instilled with the application stereochemistry, thermodynamic and kinetic aspects of various reaction used in explanations of obtained results.

Course learning objectives

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

CLO 1 Understand the role of various electronic factors (such as inductive, electromeric, resonance and mesomeric effects) in various physical and chemical properties like stability, polarity, acidity, basicity etc. of different organic species of both neutral and charged in nature. (Understand and Learn)

CLO 2 Understand basic idea on aromaticity and its influence in stabilizing ring compounds and ions. (Understand and Apply)

CLO 3 Learn and understand conformational analysis of cycloalkane and stability of various forms of conformations, assignment of equatorial and axial substituent systems. Types of reactions and mechanisms. Potential energy diagrams, transition states and intermediates, Thermodynamic and kinetic requirements, Hammond's postulate, Curtin-Hammett principle (Associate and correlate)

CLO 4 Rank the relative rates of substitutions or eliminations reactions, based on differences in substrate, base/nucleophile, leaving group, or solvent. (Arrange and Assimilate)

CLO 5 Assess and predict whether a reaction will be first-order or second-order. When possible, predict predominance of substitution or elimination. Identify reactants that could produce target chemical products. (Apply and develop)

Mapping of CLOs with PLOs

	CLO1	CLO2	CLO3	CLO4	CLO5
PLO1	3	3	3	2	2
PLO2	2	3	3	3	2
PLO3	1	2	3	3	3
PLO4	1	1	2	3	3
PLO5	1	1	1	2	3
PLO6	1	1	1	1	2
PLO7	1	1	1	1	1
	CLO1	CLO2	CLO3	CLO4	CLO5
PSO1	3	3	3	2	2
PSO2	3	3	3	3	2
PSO3	2	3	3	3	2
PSO4	3	3	3	3	2
PSO5	2	2	2	3	3
PSO6	2	2	2	2	3
PSO7	1	2	2	2	3
PSO8	1	1	1	2	3
PSO9	1	1	1	1	3

Course structure

Unit I **(12 Hours)**

Nature of Bonding in Organic Molecules: Delocalized chemical bonding-conjugation, cross conjugation, resonance, hyperconjugaton, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alterant and non-alternant hydrocarbons, Huckel's rule, energy level of π-molecular orbitals, annulenes, anti-aromaticity, Ψ-aromaticity, homo-aromaticity, PMO approach. Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds- cyclodextrins, catenanes and rotaxanes.

Unit II **(12 Hours)**

Stereochemistry: Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding. Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, sterospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Unit III **(12 Hours)**

Reaction Mechanism: Structure and Reactivity: Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Hard and soft acids and bases.

Generation, structure, stability and reactivity of carbocations. carbanions, free radicals, carbenes and nitrenes.

Effect of structure on reactivity- resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation. (16)

Unit IV **(12 Hours)**

Aliphatic and Aromatic Nucleophilic Substitution: The S_N2, S_N1, mixed S_N1 and S_N2 and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations. The S_N1 mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

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 Hydrolysis of esters and amides, Ammonolysis of esters. (16hrs)

Books Recommended:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Syks, Longman
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold Cornell University Press
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O. House, Benjamin.

7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
8. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmilan.
9. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
10. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

Teaching Learning Process:

1. The teaching Learning Progression for the course is student centric
2. Intelligent blend of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

Assessment Methods:

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts.

Keywords:
Aromaticity, Huckel's rule and Mobius aromaticity, Optical Purity, Curtin Hammett principle mechanism, Physicochemical descriptors, conjugated, fused and extended aromaticity

Semester – I
Paper Code: MCHCC – 103 **Paper Title: Inorganic Chemistry – I**
Total Credits: 3, Total Lectures: 50

Objectives: The Course provide understanding of the Chemical periodicity and structure of the molecule. The transition metals have a special property of forming coordination complexes. This is due to the high charge to mass ratio and the availability of d-orbitals. The advances in coordination chemistry provide various complex compounds that we use in various industries. These include mining & metallurgy, medical sciences etc. to name a few. Many of the biological compounds are coordination complexes e.g., haemoglobin, myoglobin, chlorophyll etc. There are numerous other coordination compounds that play an important role in biological processes.

Course Learning Objectives:

At the end of this semester, each student will be able to:

CLO 1 Understand the trend of periodic properties viz atomic/ionic radii, ionization energy, electron affinity and electronegativity. (Cognitive level – understand)

CLO 2 Understand the advanced theories of bonding, i.e., valance bond theory, crystal field theory and molecular orbital theory. (Cognitive level – understand)

CLO 3 Analyse the role of metal complexes in biological system and describe the biological significance of Na, K, Mg, Ca, Fe, Co, Ni, Cu and Zn. Explain the structure and function of haemoglobin and chlorophyll. (Cognitive level – analyse)

CLO 4 Discuss the classification & characteristics of the solvents and explain the reactions in non-aqueous solvents like liquid NH_3 and H_2SO_4. (Cognitive level – evaluate)

CLO 5 Describe electronic configuration, stable oxidation states, role of lanthanide contractions and magnetic properties of Lanthanides and Actinides. (Cognitive level – evaluate)

CLO 6 Develop a procedure for the complex formation of different transition metal ions. (Cognitive level – create)

Mapping of CLOs with PLOS

	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6
PLO-1	2	2	3	2	3	2
PLO-2	3	2	2	3	2	3
PLO-3	2	2	3	2	2	3
PLO-4	3	2	2	3	3	2
PLO-5	2	3	2	3	3	2
PLO-6	2	3	3	2	3	2
PLO-7	3	2	3	2	2	3
PSO-1	2	2	3	2	2	3
PSO-2	2	3	2	3	3	2
PSO-3	3	3	2	3	3	3
PSO-4	2	2	3	3	3	3
PSO-5	3	3	3	2	2	3
PSO-6	3	3	2	2	2	2
PSO-7	2	2	3	3	3	2
PSO-8	3	3	2	3	2	3
PSO-9	3	3	2	3	3	3

Course structure

UNIT-I (**12 Hours**)

Chemical periodicity & Structure of molecules and stereochemical non-rigidity: Fundamental trends-First and second row anamalies-The diagonal relationship-The use or not of d orbitals by nonmetals- periodic anamalies of nonmetals and post transition elements-inert pair effect- - VSEPR rules-Structures of molecules containing lone pairs of electrons-Walsh diagrams-AH_2 molecules-Bent's rule -covalent radii- van der Waals radii- Experimental determination of molecular structure- atomic inversion- Berry pseudo-rotation-fluxional organometallic compounds-Effects of chemical forces-melting, boiling points and solubility.

UNIT-II (**12 Hours**)

Concepts of acids and bases- Non-aqueous solvents- Main group elements: Bronsted & Lowry-Lux & Flood- Lewis definitions-a generalized acid-base concept- measures of acid-base strength-Steric & solvation effects and acid base anamalies-Hard-Soft acid base concept- acid base strength and hardness and softness- symbiosis- theoretical basis- effect of electronegativity-Non-aqueous solvents-ammonia- sulphuric acid-protonic solvents-aprotic solvents-molten salts-hydrometallurgy- Main group elements- allotropy, synthesis, structure and bonding of their compounds- Boron cage compounds-higher boranes- classifications-Wades' rules-carboranes-metallacarboranes-structure predictions for heteroboranes.

UNIT-III (**12 Hours**)

Transition elements and coordination compounds: valence bond theory-hybridization-inner orbital-outer orbital complexes-crystal field theory-octahedral-tetrahedral -tetragonal symmetries-crystal field stabilization energy-factors affecting CFSE-Molecular orbital theory of octahedral, tetrahedral and square planar complexes-p-bonding and molecular orbital theory-electronic spectra-term symbols and splitting of terms- correlation-Orgel and Tanabe-sugano diagrams-calculations of Dq, B and b parameters- tetragonal distortions and Jahn-Teller theorem-LMCT and MLCT-spectra-magnetic properties of complexes-substitution reactions in square planar and octahedral metal complexes- trans effect-aquation and anation reactions-reaction rates influenced by acids and bases- redox reactions- inner sphere and outer sphere reaction mechanisms- excited state outer sphere electron transfer reactions.

UNIT-IV (**14 Hours**)

Inner transition elements & Bioinorganic chemistry: The lanthanide and actinide elements-stable oxidation states- lanthanide-actinide contraction- the f-orbitals- absorption spectra-magnetic properties- coordination chemistry-comparison with transition metal complexes-Lanthanide chelates- transactinide elements- periodicity of translawrencium elements-Bioinorganic chemistry: photosynthesis- chlorophyll- porphyrins- heme group- cytochromes-metalloenzymes, carboxy peptidase- carbonic anhydrase- hemoglobin- myoglobin and oxygen transport, dioxygen complexes-vitamin B_{12} and coenzyme B_{12}-electron- transfer reactions; iron-sulphur proteins- rubredoxins and ferredoxins- blue copper proteins- hemocyanins and hemerythrins- nitrogenases- nitrogen cycle and *in vivo* nitrogen fixation, metal complexes in medicine- cis platin- essential and trace elements in biological systems.

Books Recommended:

1. Advanced Inorganic Chemistry, 6th ed. - F.A. Cotton, G. Wilkinson, Wiley 1999
2. Inorganic Chemistry, 4th ed. - J.E. Huheey, Harpis and Row
3. Inorganic Chemistry- Wulfsberg (Viva, 20020
4. Chemistry of the Elements 2nd ed. – N.N. Greenwood, A. Earnshaw, Pergaman
5. Inorganic Chemistry, 3rd ed. – D.F. Shriver, P.W. Atkins (Oxford, 1999)
6. Coordination Chemistry – D. Banerjee (Tata McGraw Hill, 1993)

Teaching Learning Process:

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars.
- Technology-driven Learning

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
    - Class Tests, Worksheets and Quizzes
    - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.

Keywords:
VSEPR, Walsh diagrams, non-aqueous solvents, CFSE, Jahn-Teller theorem, nomenclature, isomerism, Chelate effect, Latimer & Bsworth diagrams, oxidation states, lanthanide, Metal ions in biological systems.

SEMESTER I
PAPER CODE: MCHCC-104 **PAPER TITLE: ANALYTICAL CHEMISTRY**
Total Credits: 3; Total Lectures: 50

Objectives: The primary objective of this course is to acquire basic concepts, principles, process and instrumentation of various chromatographic techniques viz TLC, GC, HPLC, SEC, IEC as well as concepts of nuclear and radiation chemistry including radiation detection and measurement besides understanding the principle, instrumentation, data interpretation and applications of thermo-analytical techniques viz, TGA, DTA, DSC. This would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to.....

CLO 1 Get an insight into the basic and fundamental concepts of adsorption characteristics and adsorption isotherms. (Cognitive level: Remember, understand)

CLO 2 Remember the concepts of nuclear and radiation chemistry including radiation detection and measurement besides gaining knowledge about the principle, instrumentation, data interpretation, and applications of thermoanalytical techniques viz, TGA, DTA, DSC (Cognitive level: Remember, understand)

CLO 3 To acquire a detailed knowledge of the types and techniques of chromatography. Mechanism of separation in chromatography with clear concepts and finer details of the plate theory and rate theory of chromatography. (Cognitive level: Remember, understand)

CLO 4 Understand the theoretical and instrumentation aspects of the HPLC and GC techniques and their troubleshooting factors.

CLO 5 To analyze and interpret the GPC/GFC and ion IEC chromatograms (Cognitive level: analyse) Apply the concepts of these techniques for purification and separation

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO1.	3	3	3	2	3	2
PLO2.	3	3	3	3	2	2
PLO3.	2	3	3	2	3	3
PLO4.	2	3	3	3	2	2
PLO5.	3	3	3	2	3	3
PLO6.	2	2	2	2	2	3
PLO7.	2	2	2	2	2	3
PSO1	3	3	3	2	3	2
PSO2	3	3	3	2	2	2
PSO3	3	3	3	2	2	2
PSO4	2	2	2	3	3	3
PSO5	3	2	3	3	2	2
PSO6	2	2	2	3	3	2
PSO7	2	2	3	2	3	3
PSO8	2	2	2	2	2	3
PSO9	2	2	2	3	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit I **[15 Hours]**

Adsorption/Partition Chromatography: Kinds of adsorption interactions, adsorption characteristics, chromatographic mechanism, classification of chromatography.

TLC- Principle, phases-silica, alumina, plate loading-analytical vs. preparative, visualization, limits of detection and quantitation, factors affecting separation

Column Chromatography. Principle, types and techniques of column chromatography, techniques of elution. Theoretical aspects - theoretical plates, K-values, solute mobilities. Operating parameters.

Unit II **[11 Hours]**

Gas-liquid chromatography: Instrumentation, carrier gas, columns, solid supports, liquid phases, coating of support, sample preparation and introduction, retention time, Applications of GC.

High Performance Liquid Chromatography: Instrumentation- mobile phase reservoirs, pumping system, sample injection system, columns, detectors, operating parameters, retention times vs. volumes. Reverse phase HPLC, chiral HPLC, semi-preparative and preparative HPLC, Applications of HPLC.

Unit III **[11 Hours]**

Size Exclusion chromatography: Theory. Supports- Hydrophillic gels, soft gels, hard gels, organo and lipophilic gels. Experimental design- choice of column, support and eluent, optimization of flow rate and loading. Experimentral methods- column preparation, sample application. Applications- desalting, molecular weight and polydispersity determination, determination of equilibrium constant,

Ion exchange chromatography: Resins- strong acid and base, weak acid and base. working parameters, chromatographic procedures - displacement chromatography, elution chromatography, gradient elution, column load, size and flow rate, column packing, solvent choice, liquid ion exchangers applications of ion exchangers.

Unit IV **[13 Hours]**

Nuclear Radiation methods: Nuclear reactions and radiations, interaction of nuclear radiation with matter, radioactive decay measurements, ionization chamber, proportional counter, Geiger-Muller counter, scintillation counter, semi-conductor detectors,

Thermal and Calorimetric methods of Analysis: Basics, methodology and applications of Thermogravimetric analysis, Differential thermal analysis and Derivative thermogravimetry. Interpretation of TGA and DTA curves of important compounds e.g., calcium oxalate monohydrate, magnesium oxalate monohydrate. Analysis of silver-copper alloy and dolomite

Books recommended

1. Fundamentals of Analytical chemistry, D. A. Skoog; D. M. West; F. J.Holler, Harcourt college publications.
2. Principles and practice of analytical chemistry, F. W. Fifield; D. Kealey, Blackwell publication.
3. Analytical chemistry, G.D. Christian, Wiley and sons publication.
4. Handbook of instrumental techniques for analytical chemistry, F. A Settle, Prentice Hall Publication.
5. Analytical chemistry- Instrumental Techniques (Vol. II); M. Singh, Dominant publishers.
6. Basic concepts of analytical chemistry, S. M. Kopper, New Age International Publishers.
7. Analytical chemistry, D. Kealey, P.J.Haines, Viva books Pvt. Ltd.

Teaching Learning Process:

- The teaching-learning process for the course is student-centric
- Transaction through an intelligent mix of conventional and modern methods.

- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of students' learning.
  - Class Tests, Worksheets, Quiz
  - Presentations by individual students/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning of theoretical concepts and practical skills acquired in the lab.

Keywords:
Adsorption, Partition, theoretical plates, retention time, distribution coefficients, capacity factor, normal phase chromatography, reversed-phase chromatography, isocratic and gradient elution, ion exchangers, column packing

SEMESTER I
PAPER CODE: MCHCC-105
PAPER TITLE: LAB COURSE IN PHYSICAL CHEMISTRY – I
Total Credits: 03 Total Lectures: 40

Objectives: The lab course in physical chemistry-I is designed to strengthen the basic and fundamental concepts of physical chemistry. The course is imbued with the applications of various concepts (pH-metry, Refractometry, spectrophotometry, viscometry, chemical kinetics, and calorimetry) in estimating the various chemical compositions that are encountered in the society.

Course Learning Objectives:

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

- **CLO 1.** Understand and explain the different nature and behaviour of chemical systems and their physical properties (Understand and analyze)
- **CLO 2.** Learn and understand many day today chemical systems including their spectroscopic attributes (Remember and understand).
- **CLO 3.** Evaluate the composition of day to-day reaction mixtures by recalling and correlating the fundamental properties of the reactants involved (Analyze and evaluate).
- **CLO 4.** Use the fundamental pH, calorimeter and viscometry concepts to identify and analyse reaction mixture properties and hence mechanisms (Analyze and evaluate).
- **CLO 5.** Use the fundamental refractometry concepts to follow the chemical transformations in the laboratory while carrying out a reaction useful to society (Analyze and evaluate).

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	**3**	**3**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**
PSO1	**3**	**3**	**2**	**2**	**2**
PSO2	**3**	**3**	**2**	**2**	**2**
PSO3	**3**	**3**	**3**	**2**	**2**
PSO4	**2**	**2**	**2**	**3**	**3**
PSO5	**2**	**2**	**3**	**3**	**2**
PSO6	**2**	**2**	**2**	**3**	**3**
PSO7	**2**	**2**	**2**	**3**	**3**
PSO8	**2**	**2**	**2**	**2**	**3**
PSO9	**2**	**2**	**2**	**2**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

The experiments shall be covered from the following practical course:

A: pH-metry

1. Determination of strength and pK value of a weak acid by titration with an alkali.
2. Determination of degree of hydrolysis of aniline hydrochloride.

B: Refractometry

3. Determination of refractive index of some liquids and finding the composition of a binary liquid mixture by refractivity method.
4. Determination of molar refraction, molar polarization and electron polarisability of liquids.

C: Spectrophotometry

5. Establishing the validity of Beer-Lambert law.
6. Determination of composition of a binary mixture of $K_2Cr_2O_7$ and $KMnO_4$.

D: Viscometry

7. Investigation of variation of viscosity with conc. and determination of unknown concentration.
8. Determination of the radius of a molecule by viscosity measurement.

E. Chemical Kinetics

9. Study of kinetics of hydrolysis of an ester catalysed by dil. HCl.
10. Determination of order of reaction between $K_2S_2O_8$ and KI by Initial rates method.

F. Calorimetry

11. Determination of heat of neutralization of a strong acid with a strong base.
12. Determination of heat of neutralization of a weak acid with a strong base.

Suggested Reading

1. Practical Physical Chemistry, Findley, Kitchener, Longman, 1977.
2. Advanced Practical Physical Chemistry, Yadav, Goel Pub, 1994.
3. Experiments in Physical Chemistry, 5th ed., Schoemaker et al., MGH, 1989.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets.
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

pH-metry, Refractometry, Spectrophotometry, Viscometry, Chemical Kinetics, Calorimetry.

Semester – I
Paper Code: MCHCC – 106 **Paper Title: Lab Course in Inorganic Chemistry – I**
Credit: 3, Total Hours: 100

Objectives: Qualitative analysis involves determining metallic and non-metallic elements ions present in a given sample. Chromatography is widely used in biochemical research for the separation and identification of chemical compounds of biological origin. In the petroleum industry the technique is employed to analyze complex mixtures of hydrocarbons.

Course Learning Objectives:

At the end of this semester, each student will be able to:

CLO 1 Understand the procedure of the identification of the ions from the sample. (Cognitive level – understand)

CLO 2 Understand the technique of chromatography for the separation of the ions. (Cognitive level – understand)

CLO 3 Employ the procedures and techniques for the identification of the sample. (Cognitive level – apply)

CLO 4 Analyze the inorganic sample qualitatively. This will help to work in laboratory to find out the chemical composition from an unknown inorganic compounds or mixture of compounds. (Cognitive level – analyse)

CLO 5 Describe the results obtained from the unknown sample. (Cognitive level – evaluate)

CLO 6 Develop and formulate analytical procedures based on the techniques taught. (Cognitive level – create)

Mapping of CLOs with PLOS

	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6
PLO-1	2	2	3	2	3	2
PLO-2	3	2	2	3	2	3
PLO-3	2	2	3	2	2	3
PLO-4	3	2	2	3	3	2
PLO-5	2	3	3	3	3	2
PLO-6	2	3	3	3	3	2
PLO-7	3	2	2	2	2	3
PSO-1	3	2	2	2	2	3
PSO-2	2	3	2	3	3	2
PSO-3	3	3	2	3	3	3
PSO-4	2	2	3	3	3	3
PSO-5	2	3	3	2	2	3
PSO-6	3	2	2	2	2	2
PSO-7	2	2	3	3	3	2
PSO-8	2	3	2	2	3	3
PSO-9	3	3	3	3	3	3

The experiments shall be covered from the following practical course:

Qualitative Analysis: (40 hours)

a) Systematic qualitative analysis and identification of cations using group reagents including those of less common elements, Tl, Mo, W, Ti, Zr, Th, V, U, Li.

b) Identification of anions including insoluble sulphates, oxides and halides.

Chromatography: (60 hours)

c) Paper chromatographic separation of ions such as (i) Ag(I) & Pb(II); (ii) Cu(II), Pb(II), Bi(III) & Cd(II); (iii) Ni(II), Co(II) & Zn(II); (iv) Ba(II), Sr(II) & Ca(II); (v) F^-, Cl^-, Br^- & I^-

d) Column chromatographic (on ion exchange resin) separation and estimation of strength of (i) Zn(II) & Mg(II).

Books Recommended

1. Vogel's qualitative Inorganic Analysis; 6th edn; Svehla (Longman, 1994
2. The physical Chemistry of Inorganic Qualititative analysis; Kuriacose, Rajaram (Tata MGH, 1972)
3. Vogel's Textbook of Quantitative chemical Analysis; 5th edn; Jeffery, Bassett; (ELBS, 1989)
4. Quantitative Analysis; 6th edn; Day, Underwood (Printice Hall, 1993).
5. Chromatographic Methods; 3rd ed; Stock & Rice (Chapman & Hall, 1980).
6. Analytical Chemistry; 5th ed; D. Christian (Wiley)

Teaching Learning Process:

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars.
- Technology-driven Learning

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.

Keywords:

Qualitative analysis, Chromatography, identification, separation, metallic ions, non-metallic ions, sulphate, oxide, halide.

SEMESTER I
PAPER CODE: MCHCC-107
PAPER TITLE: LAB. COURSE IN ORGANIC CHEMISTRY-I
Total Credits: 03, Total Lectures: 40

Objectives: The core course Lab. course in Organic Chemistry-Iis designed to offer practical experience of various experiments and hands-on training of different instruments. The course comprises of qualitative analyses of mono and bifunctional compounds (detection of functional groups& group tests for compounds of natural origin); Determination of specific rotation and resolution of racemic mixtures; Quantitative estimations (of Carbohydrates, amino acids, proteins, Carboxylic acids, Phenols/Aniline);Separation& Purification of Organic compounds from a two-component mixture based on solubility&chemical properties; Analytical and preparative TLC; Small scale organic synthesis (Preparation of oximes, 2,4-dinitrophenylhydrazone, isoamyl acetate, substituted acetamide and benzamide from amines, *p*-bromoacetanilide from Aniline, 2- and 4-nitrophenols, Cyclohexanol from cyclohexanone, adipic acid from oxidation of cyclohexanol by chromic acid, Benzimidazole from *o*-phenylenediamine, dibenzalacetone and Alkylation, sulphonation, nitration and chlorination of aromatic compounds) and functional group identification of simple organic compounds using UV and IR.

Course Learning Objectives:

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

CLO 1. Recapitulate the basic concepts of about functional groups, optical activity, optical rotation and specific rotation, Thin Layer Chromatography (TLC) and IR & UV spectroscopic analysis of organic compounds. (Cognitive level: Recapitulate)

CLO 2. Practically analyze and detect the organic functional groups and the compounds of natural origin qualitatively. Estimate the carbohydrates, amino acids, proteins, carboxylic acids, phenols/aniline quantitatively. Understand the basic reactions involved in the quantitative analysis. Apply the concepts for the quantitative analysis of unknown sample. (Cognitive level: Analyze)

CLO 3. Determine the specific rotation of optically active compounds and separate the racemic mixture into pure enantiomers practically. (Cognitive level: Evaluate)

CLO 4. Practically separate a two-component mixture based on solubility and chemical properties. Analyze the number of compounds present in the given mixture using analytical TLC and separate the mixture of compounds using preparative TLC technique. (Cognitive level: Analyze)

CLO 5. Practically prepare of different oximes (acetophenone oxime/ cyclohexanone oxime/vanillin oxime), 2,4-dinitrophenylhydrazone, isoamyl acetate, substituted acetamide and benzamide from amines, Alkylation, sulphonation, nitration and chlorination of aromatic compounds, p-bromoacetanilide from Aniline, 2- and 4-nitrophenols (nitration and separation by steam distillation), Cyclohexanol from

cyclohexanone (LAH reduction), adipic acid from oxidation of cyclohexanol by chromic acid, Benzimidazole from benzyl, dibenzalacetone. Analyze the reactions and practically monitor the progress of the reactions. Understand the mechanisms of the reaction. Analyze the products formed using IR & UV spectroscopic techniques. (Cognitive level: synthesis and anlyze)

CLO 6. Apply the acquired knowledge in conducting new reactions and analyze simple organic compounds using spectroscopic techniques. (Cognitive level: Aply)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO 1.	**3**	**3**	**2**	**2**	**2**	**2**
PLO 2.	**3**	**3**	**2**	**2**	**2**	**2**
PLO 3.	**3**	**3**	**2**	**2**	**2**	**2**
PLO 4.	**2**	**3**	**3**	**2**	**2**	**2**
PLO 5.	**2**	**2**	**3**	**3**	**2**	**2**
PLO 6.	**2**	**2**	**2**	**3**	**3**	**3**
PLO 7.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 1.	**3**	**3**	**2**	**2**	**2**	**2**
PSO 2.	**3**	**3**	**2**	**2**	**2**	**2**
PSO 3.	**3**	**3**	**3**	**2**	**2**	**2**
PSO 4.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 5.	**2**	**2**	**3**	**3**	**2**	**2**
PSO 6.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 7.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 8.	**2**	**2**	**2**	**2**	**3**	**3**
PSO 9.	**2**	**2**	**2**	**2**	**3**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

The experiments shall be covered from the following practical course:

1. Qualitative Analysis of mono and bifunctional compounds
   a. Detection of Functional Groups
   b. Group tests for compounds of natural origin
2. Determination of specific rotation and resolution of racemic mixtures
3. Quantitative estimation of the following:
   Carbohydrates, amino acids, proteins, Carboxylic acids, Phenols/Aniline
4. Separation, Purification and Identification of Organic compounds from a two-component mixture
   Separation based on solubility in water.
   Separation based on solubility in organic solvents.
   Separation based on chemical properties: Solubility in Sodium Bicarbonate, Sodium Hydroxide and Hydrochloric acid
5. Analytical and preparative TLC
6. Small scale organic synthesis
   i. Preparation of oximes (acetophenone oxime/ cyclohexanone oxime/vanillin oxime)
   ii. Preparation of 2,4-dinitrophenylhydrazone
   iii. Preparation of isoamyl acetate
   iv. Preparation of substituted acetamide and benzamide from amines.

v. Alkylation, sulphonation, nitration and chlorination of aromatic compounds
vi. Preparation of p-bromoacetanilide from Aniline
vii. 2- and 4-nitrophenols (nitration and separation by steam distillation)
viii. Cyclohexanol from cyclohexanone (LAH reduction)
ix. Preparation of adipic acid from oxidation of cyclohexanol by chromic acid
x. Benzimidazole from benzyl
xi. Preparation of dibenzalacetone.

7. UV and IR of simple organic compounds for functional group identification

Books Recommended

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miler, Prentice Hall
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath
3. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley
4. Chemistry of Natural Products: A laboratory Handbook by N.R. Krishnaswamy, University Press, 2003
5. Comprehensive Practical Organic Chemistry, V.K. Ahluwalia, Renu Agarwal (University Press India Ltd.-2000)
6. Organic Laboratory techniques, Donald C Pavia, Gary M Lampman.
7. Experimental Organic Chemistry John C Gilgert, Stephen F Martin.(SCP)
8. Advanced Practical Organic Chemistry, Vol.II, Jagmohan (Himalaya Publishing House)

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative and practical learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets. Viva-voce exams
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Qualitative Analysis, Quantitative Analysis, specific rotation, Separation, Purification, Analytical and preparative TLC, Small scale organic synthesis

Semester - II
Scheme of courses

SEMESTER II
PAPER CODE: MCHCC-201 **PAPER TITLE: PHYSICAL CHEMISTRY-II**
Total Credits: 03 Total Lectures: 50

Objectives: The course describes the basic theory of physical chemistry like chemical kinetics, surface chemistry, and statistical mechanics applied to chemical systems. The course also provides an insight into the experimental determination of the rate law of chemical reaction and how these can be employed to solve reaction mechanisms. After completing this course should be able to solve the kinetic aspect of a reaction structure by identifying various intermediates of the reaction and the fractional occupancy of each energy level in the energy diagram.

Course Learning Objectives:

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

CLO 1 Gain insight into basic principles of chemical kinetics, surface chemistry, and Statistical mechanics (Remember and understand).
CLO 2 Learn about methods of determination rate laws of compounds by chemical kinetics (Remember and understand).
CLO 3 Learn about the surface chemistry and statistical aspect of these chemical systems (Remember and understand).
CLO 4 Understand instrumental modalities of the kinetic-based experiments (Understand and analyze).
CLO 5 Identify and follow the rate of the different chemical reactions (Understand and analyze).
CLO 6 Use spectroscopic and other optical techniques to determine the rate of reaction of a known and unknown reaction (Apply and evaluate).
CLO 7 Develop and formulate analytical procedures based on the techniques taught (Apply and create).

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO1.	3	3	3	2	2	2
PLO2.	3	3	3	2	2	2
PLO3.	2	3	3	2	2	2
PLO4.	2	3	3	3	2	2
PLO5.	2	2	2	2	3	3
PLO6.	2	2	2	2	2	3
PLO7.	2	2	2	2	2	3
PSO 1.	3	3	3	2	2	2
PSO 2.	3	3	3	2	2	2
PSO 3.	3	3	3	2	2	2
PSO 4.	2	2	2	3	3	3
PSO 5.	2	2	3	3	2	2
PSO 6.	2	2	2	3	3	2
PSO 7.	2	2	2	2	3	3
PSO 8.	2	2	2	2	2	3
PSO 9.	2	2	2	2	2	3

Course structure

Unit I

Chemical Dynamics I: Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.

Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen–bromine and hydrogen- chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction)

Unit II

Chemical Dynamics II: Homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method. Dynamics of molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions).

Unit – III

Concept of distribution, thermodynamic probability and most probable distribution: Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws using lagranges method of undetermined multipliers). Partition functions: translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Fermic Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics – distribution law and application to helium.

Unit – IV

Micelles: 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, solubilization, micro emulsion, reverse micelles.

Books recommended

1. Physical Chemistry, P.W. Atkins, ELBS
2. Chemical Kinetics, K.J. Laidler, Mcgraw Hill
3. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman ; J. Kuriacose, McMillan publications
4. Micelles, Theoretical and Applied Aspects, V. Moroi, Plenum Publications.
5. Stastical Mechanics by D. Nash

Suggested Reading

1. Practical Physical Chemistry, Findley, Kitchener, Longman, 1977.
2. Advanced Practical Physical Chemistry, Yadav, Goel Pub, 1994.
3. Experiments in Physical Chemistry, 5th ed., Schoemaker et al., MGH, 1989.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets.
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Conductometry, phase equilibria, potentiometry, polarimetry, redox potential.

SEMESTER II
PAPER CODE: MCHCC -202 PAPER TITLE: ORGANIC CHEMISTRY - II
Total Credits: 03, Total Lectures: 50

Objectives: The core course Organic Chemistry-II is designed to understand the reaction mechanisms of aliphatic electrophilic substitution; free radical reactions; addition to Carbon-Carbon multiple bonds and elimination Reactions**.**

The course consists of aliphatic electrophilic substitution reactions including S_E1, S_E2 & S_Ei and various factors influencing these reactions; Aromatic electrophilic substitutions including the arenium ion mechanism, ortho/para ratio, ipso attack, orientation in other ring systems, Diazonium coupling, Vilsmeir reaction & Gattermann-Koch reaction; different types of free radical reactions including free radical substitution mechanism, the mechanism at an aromatic substrate & neighbouring group assistance etc.; additions to Carbon-Carbon & Carbon-Hetero multiple bonds involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity and different types of elimination reactions including E2, E1 & E1cB mechanisms.

Course Learning Objectives:

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

CLO 1. Recapitulate the basic concepts of addition, elimination and substitution reactions involving nucleophiles, electrophiles and free radicals. **(Cognitive Level: Remember)**

CLO 2. Understand the concepts of aliphatic bimolecular and unimolecular electrophilic substitutions including Bimolecular mechanisms- S_E2, S_Ei & S_E1 mechanisms; electrophilic substitution accompanied by double bond shifts; Effect of substrates, leaving group & the solvent polarity on the reactivity and Aromatic Electrophilic Substitutions including the arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems; Quantitative treatment of reactivity in substrates and electrophiles; Diazonium coupling, Vilsmeir reaction and Gattermann-Koch reaction. **(Cognitive Level: understand)**

CLO 3. Learn and understand different types free radical-mediated reactions including free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance, the reactivity of aliphatic and aromatic substrates at a bridgehead, reactivity in the attacking radicals, the effect of solvents on reactivity, Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, the Sandmeyer reaction and Free radical rearrangements, the Hunsdieker reaction. **(Cognitive Level: understand)**

CLO 4. Comprehend various addition reactions of Carbon-Carbon & Carbon-Hetero multiple bonds involving electrophiles/nucleophiles/free radicals including addition of cyclopropane ring, hydrogenation of double & triple bonds, hydrogenation of aromatic rings, hydroboration, michael reaction, sharpless asymmetric epoxidation; mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds acids, esters & nitriles; addition of Grignard reagents, organozinc & organolithium reagents to carbonyl and unsaturated carbonyl compounds; wittig reaction and the mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Also learn about different types of elimination reactions including E2, E1 & E1cB mechanisms and the factors influencing their reactivity. **(Cognitive Level: analyze and evaluate)**

CLO 5. Apply different addition/elimination/substitution reactions in organic synthesis and create some new reactions based on the knowledge gained from this course. **(Cognitive Level: apply)**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	**3**	**3**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**
PSO1	**3**	**3**	**2**	**2**	**2**
PSO2	**3**	**3**	**2**	**2**	**2**
PSO3	**3**	**3**	**3**	**2**	**2**
PSO4	**2**	**2**	**2**	**3**	**3**
PSO5	**2**	**2**	**3**	**3**	**2**
PSO6	**2**	**2**	**2**	**3**	**3**
PSO7	**2**	**2**	**2**	**3**	**3**
PSO8	**2**	**2**	**2**	**2**	**3**
PSO9	**2**	**2**	**2**	**2**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit I **[13 Hours]**

Aliphatic Electrophilic Substitution: Bimolecular mechanisms- S_E2 and S_Ei. The S_E1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity. Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

Unit II: **[12Hours]**

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

Unit III **[13 Hours]**

Addition to Carbon-Carbon Multiple Bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity, addition of cyclopropane ring, hydrogenation of double and triple bonds, hydrogenation of aromatic rings, hydroboration, michael reaction, sharpless asymmetric epoxidation. Addition to Carbon-Hetero Multiple Bonds: mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds acids, esters and nitriles, addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, wittig reaction, mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

Unit IV **[12 Hours]**

Elimination Reactions: The E2, E1 and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

Books Recommended:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Syks, Longman
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold Cornell University Press
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
8. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmilan.
9. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
10. Stereochemistry of Organic Compounds, P. S. Kalsi, New Age International.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning.
  - Class Tests, Worksheets.
  - Assignments, projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Aliphatic Electrophilic Substitution, ipso attack, Free Radical Reactions, Addition to Carbon-Carbon Multiple Bonds, Elimination Reactions.

Semester – II
Paper Code: MCHCC – 203 **Paper Title: Inorganic Chemistry**
Total Credits: 3 Total Lectures: 50

Objectives: The selective course of inorganic chemistry is designed to strengthen the basic and fundamental concepts of organometallic, and bioinorganic chemistry, inorganic spectroscopy, solid state and group theory. Organometallic compounds have played a critical role in catalysis and organic synthesis, often leading to more efficient use of reagents, higher yields of products, and less use of energy. Bioinorganic chemistry includes the study of both natural phenomena such as the behavior of metalloproteins as well as artificially introduced metals, including those that are non-essential, in medicine and toxicology.

Course Learning Objectives:

At the end of this semester, each student will be able to:

- **CLO 1** Discuss the synthesis of metal carbonyl, metal nitrosyl, metal dinitrogen and metal carbonyl hydride clusters, non-aromatic metal complexes: metal alkenes and metal alkynes and aromatic complexes: cyclopentadienyl compounds, cycloheptatriene and tropylium complexes. (Cognitive level – understand)
- **CLO 2** Describe the reaction mechanism in carbonyl compounds: substitution, elimination, oxidative addition, reductive elimination and insertion and catalytic reactions: Hydrogenation (Wilkinson catalyst), Tolmann catalytic loop, synthesis gas ($H_2 + CO$), (hydroformylation) oxo process, Wacker process, synthetic gasoline and Ziegler-Natta catalyst. (Cognitive level – understand)
- **CLO 3** Calculate the total valence electron in the complex compounds and identify the geometry of the cluster compounds viz. closo, nido, arachno, hypo and klado. (Cognitive level – analyse)
- **CLO 4** Analyse the coordination complexes with the help of ^1H NMR, IR, EPR and Moussbaur spectroscopy. (Cognitive level – analyse)
- **CLO 5** Describe the synthesis and bonding and structure of S-N compounds, B-N compounds, P-N compounds and metal clusters. (Cognitive level – evaluate)
- **CLO 6** Describe the axis of symmetry, plane of symmetry, center of symmetry, improper axis of symmetry, identity, molecular symmetry and point group of the molecules and learn to use the point group to find out the IR and Raman active vibrations with the help of the character table. (Cognitive level – evaluate)
- **CLO 7** Explain the packing and crystal system of an ionic solid. They can find the lattice energy of ionic solids bu using Born Haber cycle. (Cognitive level – create)

Mapping of CLOs with PLOS

	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
PLO-1	2	3	2	2	3	2	2
PLO-2	3	3	2	3	2	3	3
PLO-3	2	2	3	2	3	2	3
PLO-4	3	3	3	2	3	2	2
PLO-5	2	3	2	3	2	2	2
PLO-6	2	3	3	3	3	3	3
PLO-7	3	2	3	2	2	3	3
PSO-1	2	2	3	2	2	3	2
PSO-2	2	3	2	2	2	2	2
PSO-3	3	2	2	3	3	3	3
PSO-4	2	2	3	3	2	3	3
PSO-5	3	2	3	3	2	2	2
PSO-6	2	3	2	2	3	3	3
PSO-7	2	2	3	2	3	2	2
PSO-8	3	2	2	3	2	3	3
PSO-9	2	3	2	3	3	2	3

Course structure

UNIT-I **[14 Hours]**

Organometallic compounds: 18 electron rule and counting electrons in complexes- metal carbonyl complexes- poly nuclear carbonyl complexes- carbonylate ions- carbonyl hydride complexes - isolobal fragments- Structural predictions for organometallic clusters- nitrosyl complexes- dinitrogen complexes- metal alkyls- carbenes- carbines and carbide-alkyl complexes-non aromatic alkene and alkyne complexes- metallocenes- structures of cyclopentadienyl compounds- covalent versus ionic bonding- arene complexes- cycloheptatriene and tropylium complexes- substitution reactions in carbonyl complexes- ligand cone angles- oxidative addition and reductive elimination- insertion and elimination reaction- alkene hydrogenation and Wilkinson catalyst- Tolmann catalytic loops- synthesis gas- hydroformylation- Wacker process-synthetic gasoline- Ziegler-Natta catalysis.

UNIT-II **[12 Hours]**

Inorganic rings, cages, polymers and metal clusters: synthesis, structure and bonding of S-N compounds- B-N compounds- P-N compounds- theries of bonding in phosphazenes- phosphazene polymers and applications-other heterocyclic ring systems- heterocatenation- silicates- intercalation compounds- isopoly acids- hetero poly acids- synthesis, structure and bonding in metal clusters- di-, tri-, tetra-, and hexa-nuclear clusters- poly atomic Zintl anions and cations- Chevrel phases- infinite metal chains.

UNIT-III **[12 Hours]**

Inorganic spectroscopy: Characterisation of inorganic compounds by IR, symmetry and shapes of AB_2, AB_3, AB_4, AB_5, AB_6 mode of bonding of ambidentate ligands, ethylene diamine and diketonato complexes- application of resonance Raman spectroscopy for the study of active site of metalloproteins- EPR spectroscopy- hyperfine coupling-g-tensors- application to transition metal complexes having one unpaired electron-including biological systems and inorganic free radicals- NMR spectroscopy of paramagnetic substances- contact and pseudo contact shifts- some applications of ^{31}P, ^{195}Pt and ^{119}Sn NMR spectroscopy- Mössbauer, basic principles- spectral parameters and spectrum display- application to the study of bonding and structures of Fe^{2+}, Fe^{3+} including those of intermediate spin.

UNIT-IV **[12 Hours]**

Chemical applications of group theory & Solid state: symmetry elements- symmetry operations- mirror plane- center of symmetry -rotational axis- identiy- improper rotation- point groups and molecular symmetry- irreducible representations and character tables- uses of point group symmetry-infrared and Raman spectroscopy- selection rules- Solid state: crystallography- crystal systems and Bravais lattices- Bragg's law and applications; the ionic bond- structures of crystal lattices- lattice energy- the Born-Haber cycle- factors affecting the radii of ions- efficiency of packing and crystal lattices- radius ratio- covalent character in ionic solids- imperfections in crystals- conductivity in ionic solids- types of solids- band structure of solids- high temperature super conductors.

Books Recommended:

1. Advanced Inorganic Chemistry, 6th ed- F.A. Cotton, G. Wilkinson, Wiley 1999
2. Inorganic Chemistry, 4th ed. - J.E. Huheey, E.A. Keiter, Harpis and Row

3. Chemistry of the Elements 2nd ed. – N.N. Greenwood, A. Earnshaw, Pergamen
4. Mechanisms of Inorganic Reactions – D. Katakis, G. Gordon (Wiley, 1987)
5. Reaction Mechanism of Inorganic and Organometallic systems, 2nd ed. – R.B. Jordan (Oxford, 1998).
6. Mechanisms of Inorganic Reactions, 2nd ed. – F. Basolo, R.G. Pearson (Wiley, 1967).
7. Inorganic Chemistry – K.F. Purcell, IC. Kotz (Saunders, 1977).
8. Electronic Spectra of Transition Metal Complexes – D. Sutton (McGraw-Hill, 1968)
9. Elements of Magnetochemistry – R.L. Dutta, A. Syamal (Affiliated East – West, 1993).
10. Inorganic Electronic Spectroscopy, A.b.P. Lever, Elsevier
11. Magnetochemistry, R.L.Carlin, Springer Verlag
12. Comprehensive Coordination Chmistry Eds., G.Wilkinson, R.D.Gillars and J.A.McCleverty, Pergamon

Teaching Learning Process:

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars.
- Technology-driven Learning

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
    - Class Tests, Worksheets and Quizzes
    - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.

Keywords:
Organometallic compounds, back bonding, Zeise's salt, Inorganic Cages, bioinorganic chemistry, metalloproteins, haemoglobin, chlorophyll, catalysis, coordination compound.

SEMESTER II
PAPER CODE: MCHCC-204 **PAPER TITLE: APPLICATIONS OF SPECTROSCOPY TO STRUCTURAL ANALYSIS**
Total Credits: 03 Total Lectures: 50

Objectives: The course describes the basic theory of spectroscopic techniques like UV/Vis., IR, and magnetic resonance applied to chemical systems. The course also provides an insight into the determination of the molecular mass of organic molecules and how these can be employed to solve chemical structures. After completing this course the student should be able to determine chemical structures by identifying various aspects of the spectrum.

Course Learning Objectives:

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

CLO 1. Gain insight into basic principles of UV, IR and NMR spectroscopic techniques. **[Cognitive level: Remember and understand]**
CLO 2. Learn about mol.wt determination of compounds by mass spectrometry. **[Cognitive level: Remember and understand]**
CLO 3. Learn about the sample preparation for these characterization techniques. **[Cognitive level: Remember and understand]**
CLO 4. Understand instrumental modalities of the spectroscopic techniques. **[Cognitive level: Understand]**
CLO 5. Identify different compounds using chemical characterization methods **[Cognitive level: Analyze]**
CLO 6. Use spectroscopic techniques to determine the structure and stereochemistry of known and unknown compounds. **[Cognitive level: Apply and evaluate]**
CLO 7. Develop and formulate analytical procedures based on the techniques taught **[Cognitive level: Create]**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO-1	3	3	3	2	2	2
PLO-2	3	3	3	2	2	2
PLO-3	2	3	3	2	2	2
PLO-4	2	3	3	3	2	2
PLO-5	2	2	2	2	3	3
PLO-6	2	2	2	2	2	3
PLO-7	2	2	2	2	2	3
PSO-1	3	3	3	2	2	2
PSO-2	3	3	3	2	2	2
PSO-3	3	3	3	2	2	2
PSO-4	2	2	2	3	3	3
PSO-5	2	2	3	3	2	2
PSO-6	2	2	2	3	3	2
PSO-7	2	2	2	2	3	3
PSO-8	2	2	2	2	2	3
PSO-9	2	2	2	2	2	3

Course structure

Unit I **[12 Hours]**

Ultraviolet, Visible and Luminescence Spectroscopy:

Introduction, wave-like propagation of light, absorption of electromagnetic radiation by organic molecules, allowed and forbidden transitions, absorption laws and molar absorptivity, electronic transitions, spectrophotometer and spectrum recording, effect of solvents on electronic transitions, formation and designation of absorption bands, conjugated systems and transition energies, unsaturated carbonyl compounds, dienes and conjugated polyenes, Woodward – Fieser rules. UV spectra of aromatic, heterocyclic compounds and steric effect in biphenyls. General applications of ultraviolet spectroscopy. [8 hours]

Introduction to fluorescence and Phosphorescence. Fluorescence lifetime and quantum yields, fluorescence anisotropy, instrumentation for fluorescence spectroscopy, effects of solvents on fluorescence emission spectra, mechanism and dynamics of solvent relaxation, quenching of fluorescence, applications of fluorescence spectroscopy. Principle of phosphorescence spectroscopy and its applications. [4 hours]

Unit II **[12 Hours]**

Infrared Spectroscopy: Introduction, absorption in the infrared region, theory of infrared spectroscopy, molecular vibrations, calculation of vibrational frequencies, factors affecting vibrational frequencies, characteristic absorptions in common classes of compounds, fingerprint region, characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ether, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, acids, anhydrides, lactones, lactums and conjugated carbonyl compounds), applications of infrared spectroscopy, interpretation of infrared spectra of organic compounds. IR of gaseous, solids and polymeric materials. Instrumentation – CWIR and FTIR. Basics of Raman Spectroscopy.

Unit III **[14 Hours]**

NMR Spectroscopy: Introduction, theory of NMR spectroscopy, vector model, Bloch equation, multiplicity, instrumentation, chemical shift, H-1 NMR spectroscopy- equivalent and nonequivalent protons, vicinal coupling and stereo structure, proton exchange reactions, nuclear overhauser effect (NOE), shift reagents, principle of FT – NMR. C-13 NMR spectroscopy, multiplicity- ^{1}H decoupling, noise decoupling, off- resonance decoupling, DEPT ^{13}C spectra, introduction to ^{15}N, ^{31}P and ^{19}F NMR. Interpretation of NMR spectra of some representative compounds.

Introduction of 2D NMR spectroscopy, Coherence transfer, Coherence selection, Pulse sequences - COSY, Hetero- COSY, NOESY, Interpretation of 2D NMR spectra of some representative compounds.

Unit IV **[12 Hours]**

Mass Spectrometry: Introduction, basic theory, instrumentation, important useful terms in mass spectrometry, various modes of ionization (EI, CI, FD, FAB, ESI and MALDI) and their applications, fragmentation patterns of various functional group molecular ion peak, metasable peak, Mclafferty rearrangements, nitrogen rule, GC-MS, LC-MS and their applications. Introduction to MS-MS.

Suggested Reading

1. Introduction to spectroscopy, Pavia; Lampman , Kriz, Books/cole.
2. Spectroscopic methods in organic chemistry, H. Williams; I. fleminig, Tata Mc Grawhills
3. Organic spectroscopy, W. Kemp, Palgrave publications.

4. Fundamentals of Analytical chemistry, D. A. Skoog; D. M. West; F. J. Holler, Harcourt college publications.
5. Principles and practice of analytical chemistry, F. W. Fifield; D. Kealey, Blackwell publication.
6. Analytical chemistry, G.D. Christian, Wiley and Sons publication.
7. Spectrometric identification of organic compounds, R. M. Silverstein, John Wiley and Sons publication.
8. Basic concepts of analytical chemistry, S. M. Kopper, New Age International Publishers.
9. Analytical chemistry, D. Kealey; P.J.Haines, Viva books Pvt. Ltd
10. Analytical Chemistry – Instrumental techniques, Vol. I, M. Singh, Dominent publication

Teaching Learning Process:

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods, like animations etc
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments and projects enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical applications of the concepts

Keywords:

UV, IR, NMR, Mass spectrometry, flourescence, Phosphorescence.

SEMESTER II
PAPER CODE: MCHCC-205
PAPER TITLE: LAB COURSE IN PHYSICAL CHEMISTRY – II
Total Credits: 03 Total Lectures: 40

Objectives: The lab course in physical chemistry-II is designed to strengthen the basic and fundamental concepts of physical chemistry. The course is imbued with the applications of various concepts (conductometry, phase equilibria, potentiometry and polarimetry) in estimating the various chemical compositions that are encountered in the society.

Course Learning Objectives:

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

CLO 1. Understand and explain the different nature and behavior of 2 component system and their phase equilibria (Remember and understand).

CLO 2. Learn and understand about optically active compound and estimating the unknown concentration from the calibration curve and rate constant of inversion of cane sugar catalyzed by HCl (Analyze and evaluate).

CLO 3. Formulate the mechanism of basic conductometric and potentiometric reactions by recalling and correlating the fundamental properties of the reactants (acid-base or Re-Ox pair) involved (Understand, Analyze and evaluate).

CLO 4. Use the fundamental conductometric and potentiometric titration concepts to identify and analyze reaction progress with it (Analyze and evaluate).

CLO 5. Use the fundamental phase equilibria concepts to bring about fundamental study in the laboratory and create phase diagrams which contribute to the fundamental understanding of the subject and hence useful to society
(Apply and create).

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO-1	3	3	2	2	2
PLO-2	3	3	2	2	2
PLO-3	3	3	2	2	2
PLO-4	2	3	3	2	2
PLO-5	2	2	3	3	2
PLO-6	2	2	2	3	3
PLO-7	2	2	2	3	3
PSO-1	3	3	2	2	2
PSO-2	3	3	2	2	2
PSO-3	3	3	3	2	2
PSO-4	2	2	2	3	3
PSO-5	2	2	3	3	2
PSO-6	2	2	2	3	3
PSO-7	2	2	2	3	3
PSO-8	2	2	2	2	3
PSO-9	2	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

The experiments shall be covered from the following practical course:

A: Conductometry

1. Determination of the composition of a mixture of HCl and CH_3COOH by titration with standard NaOH.
2. Determination of degree of dissociation of weak acid.

B: Phase Equilibria

3. Determination of the transition temperature of a solid.
4. Study of the phenol/water and carbon disulphide/methanol system.

C: Potentiometry

5. Determination of strength of an acid by titration with an alkali using quinhydrone electrode
6. Titration of Fe (II) vs $K_2Cr_2O_2$ and determination of standard redox potential of $Fe^{2+/}Fe^{3+}$.

D: Polarimetry

7. Determination of the specific rotation of an optically active compound and determination of unknown concentration from the calibration curve.
8. Determination of the rate constant of inversion of cane sugar catalysed by HCl.

Suggested Reading

4. Practical Physical Chemistry, Findley, Kitchener, Longman, 1977.
5. Advanced Practical Physical Chemistry, Yadav, Goel Pub, 1994.
6. Experiments in Physical Chemistry, 5th ed., Schoemaker et al., MGH, 1989.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets.
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

conductometry, phase equilibria, potentiometry, polarimetry, redox potential.

Semester – II
Paper Code: MCHCC-206 **Paper Title: Lab. Course in Inorganic Chemistry - II**
Total Credits: 3, Total Hours: 100

Objectives: Quantitative analysis is a method used for determining the amount of a chemical in a sample. The amount is always expressed as a number with appropriate units. Coordination compounds are a class of compounds that we know as the complex compounds. Coordination compounds have specific colours. Therefore, they find a common place in industries for intense colourations.

Course Learning Objectives:

At the end of this semester, each student will be able to:

CLO-1 Understand the procedure for the preparation of the coordination complexes. (Cognitive level - understand)

CLO-2 Employ the procedure for the estimation of the ions using gravimetric and volumetric methods. (Cognitive level - apply)

CLO-3 Examine the change in the physical state of the reaction mixture during preparation. (Cognitive level - analyse)

CLO-4 Analyse the synthesized complexes by IR and UV-Visible spectroscopy. (Cognitive level - analyse)

CLO-5 Describe the observations noted during the synthesis of the complexes. (Cognitive level evaluste)

CLO-6 Estimate the ions by quantitatively. (Cognitive level – evaluate)

Mapping of CLOs with PLOS

	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6
PLO-1	**2**	**2**	**2**	**2**	**3**	**3**
PLO-2	**2**	**3**	**2**	**3**	**2**	**2**
PLO-3	**2**	**2**	**3**	**3**	**3**	**2**
PLO-4	**3**	**2**	**3**	**2**	**3**	**3**
PLO-5	**2**	**3**	**2**	**3**	**2**	**3**
PLO-6	**2**	**3**	**3**	**3**	**3**	**2**
PLO-7	**3**	**2**	**2**	**2**	**3**	**3**
PSO-1	**2**	**2**	**3**	**2**	**2**	**3**
PSO-2	**3**	**3**	**2**	**2**	**2**	**3**
PSO-3	**3**	**3**	**3**	**3**	**3**	**2**
PSO-4	**2**	**2**	**3**	**3**	**2**	**2**
PSO-5	**3**	**2**	**3**	**2**	**2**	**3**
PSO-6	**3**	**3**	**2**	**2**	**2**	**2**
PSO-7	**2**	**2**	**3**	**3**	**3**	**2**
PSO-8	**2**	**3**	**2**	**3**	**3**	**3**
PSO-9	**2**	**3**	**3**	**3**	**3**	**3**

The experiments shall be covered from the following practical course:

Preparation of coordination compounds of transition metals and their characterization by IR and electronic spectra: (60 hours)

- **(i)** $VO(acac)_2$
- **(ii)** $TiO(C_9H_8NO)_2.2H_2O$
- **(iii)** Cis-$K[Cr(C_2O_4)_2(H_2O)2]$
- **(iv)** $Na[Cr(NH_3)_2(SCN)_4]$
- **(v)** $Mn(acac)_3$
- **(vi)** $K_3[Fe(C_2O_4)_3]$
- **(vii)** Prussian Blue, Turnbull's Blue
- **(viii)** $[Co(NH_3)_6][Co(NO_2)_6]$
- **(ix)** Cis-$[Co(trien)(NO_3)_2]Cl.H_2O$
- **(x)** $Hg[Co(SCN)_4]$
- **(xi)** $Co(Py)_2Cl_2$
- **(xii)** $[Ni(NH_3)_6]Cl_2$
- **(xiii)** $Ni(dmg)_2$
- **(xiv)** $[Cu(NH_3)_4]SO_4.H_2O$

Quantitative Analysis (40 hours)

(a) Estimation of cations in dictation using gravimetric and volumetric (complexometric or redox or iodometric argentometric titrations) methods like (i) Cu-Ni, (ii) Ni-Zn, (iii) Cu-Fe, (iv) Ag-Zn, (v) Fe-Ni, (vi) Cu-Mg, (vii) Ca-Mg, (viii) Zn-Mg.

Books Recommended

1. Vogel's qualitative Inorganic Analysis; 6th edn; Svehla (Longman, 1994)
2. The physical Chemistry of Inorganic Qualititative analysis; Kuriacose, Rajaram (Tata MGH, 1972)
3. Vogel's Textbook of Quantitative chemical Analysis; 5th edn; Jeffery, Bassett; (ELBS, 1989)
4. Quantitative Analysis; 6th edn; Day, Underwood (Printice Hall, 1993).
5. Chromatographic Methods; 3rd ed; Stock & Rice (Chapman & Hall, 1980).
6. Analytical Chemistry; 5th ed; D. Christian (Wiley)

Teaching Learning Process:

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars.
- Technology-driven Learning

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.

Keywords:
Coordination complexes, quantitative analysis, gravimetry, volumetry, metal ions.

SEMESTER II
PAPER CODE: MCHCC-207
PAPER TITLE: LAB COURSE IN ORGANIC CHEMISTRY – II
Total Credits: 03 Total Lectures: 40

Objectives: The lab course in Organic chemistry-II is designed to strengthen the basic and fundamental concepts of organic chemistry. The course is imbued with the applications of these concepts in synthesis or extract molecules useful to society.

Course Learning Objectives:

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

CLO 1. Understand and explain different nature and behaviour of organic compounds and their reactivities. [**Cognitive level: Remember and understand]**

CLO 2. Learn and understand many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution. [**Cognitive level: Remember and understand]**

CLO 3. Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved. [**Cognitive level: Apply and evaluate]**

CLO 4. Use the fundamental reactivity concepts to identify and analyse reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution. [**Cognitive level: Analyze]**

CLO 5. Use the fundamental reactivity concepts to bring about chemical transformations in the laboratory and synthesize small molecules useful to society or extract them from natural sources [**Cognitive level: Create]**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	**3**	**3**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**
PSO1	**3**	**3**	**2**	**2**	**2**
PSO2	**3**	**3**	**2**	**2**	**2**
PSO3	**3**	**3**	**3**	**2**	**2**
PSO4	**2**	**2**	**2**	**3**	**3**
PSO5	**2**	**2**	**3**	**3**	**2**
PSO6	**2**	**2**	**2**	**3**	**3**
PSO7	**2**	**2**	**2**	**3**	**3**
PSO8	**2**	**2**	**2**	**2**	**3**
PSO9	**2**	**2**	**2**	**2**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure:

The experiments shall be covered from the following practical course:

A: Preparation of the following

1. 2-Phenyl indole (Fischer indole synthesis),
2. 7-Hydroxy -3-methyl flavone (Baker-Venkatraman reaction),
3. Benzyl alcohol and benzoic acid from benzaldehyde (Cannizzaro reaction)
4. 4-Chlorotoluene from p-toluidine (Sandmeyer reaction)
5. Benzilic acid from benzoin (Benzilic acid rearrangement)
6. Benzopinacol from benzophenone (Photochemical reaction),
7. 7-Hydroxy-4-methyl coumarin (Pechmann Reaction)
8. 4-Methyl benzophenone (Friedal Craft reaction)
9. Benzanilide from benzophenone (Beckmann rearrangement)
10. Vanillyl alcohol from vanillin ($NaBH_4$ reduction)
11. Stilbene from benzyl chloride (Wittig reaction)
12. Ethyl cinnamate from benzaldehyde (Wittig reaction)
13. Triphenyl or diphenyl methyl carbinol (Grignard reaction)
14. Benzotriazole
15. 1-Phenyl-3-methyl pyrazol-5-one
16. Glucose pentaacetate
17. 2,4-diethoxycarbonyl-3,4-dimethyl pyrrole from ethyl acetoacetate
18. Quinoline from aniline Skraup synthesis)

B: Isolation of the following natural products.

19. Nicotine dipicrate from tobacco.
20. Caffeine from tea
21. Eugenol from clove oil.
22. R (+) Limonene and Hesperidin from orange peel.
23. Lycopene from tomatoes.
24. Piperine from black pepper.
25. β-carotene from carrots.
26. Lawsone from *Lawsonia alba*
27. Atropine from datura seeds

Suggested Reading

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miler, Prentice Hall
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath
3. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley
4. Chemistry of Natural Products: A laboratory Handbook by N.R. Krishnaswamy, University Press, 2003
5. Comprehensive Practical Organic Chemistry, V.K. Ahluwalia, Renu Agarwal (University Press India Ltd.-2000)
6. Organic Laboratory techniques, Donald C Pavia, Gary M Lampman.
7. Experimental Organic Chemistry John C Gilgert, Stephen F Martin.(SCP)
8. Advanced Practical Organic Chemistry, Vol.II, Jagmohan (Himalaya Publishing House)

Teaching Learning Process:

- The teaching Learning Process for the course is student centric

- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Baker-Venkatraman reaction, Pechmann Reaction, Isolation, nicotine, caffeine

Semester – III
Courses

SEMESTER III
PAPER CODE: MCHCCO-301 **PAPER TITLE: CHEMISTRY OF NATURAL PRODUCTS -I**
Total Credits: 03 Total Lectures: 50

Objectives: The course acquaints the learner with different classes of natural products, their biosynthetic pathways and their general reactivity apart from important techniques of identifying and characterizing them

Course Learning Objectives:

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

C.L.O 1. Get an insight into the basic and fundamental concepts of natural products chemistry. (Remember and understand)

C.L.O 2. Gain knowledge about the occurrence, distribution, different methods of isolation, and general methods of structure determination of natural products from plants. (Remember and understand)

C.L.O 3. Learn about biosynthetic pathways of different classes of natural products *viz* terpenoids, alkaloids, steroids, flavonoids. (Remember and understand)

C.L.O 4. Understand the properties of natural products, their structure-activity relationship, and their pharmacological effects. (Understand)

C.L.O 5. Identify and analyze the different classes of natural products on the basis of chemical tests (Analyze)

C.L.O 6. Apply modern analytical methods in the structure elucidation of natural products. (Apply and evaluate)

C.L.O 7. Synthesis of different classes of natural products. (Create)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	**3**	**3**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**
PSO1	**3**	**3**	**2**	**2**	**2**
PSO2	**3**	**3**	**2**	**2**	**2**
PSO3	**3**	**3**	**3**	**2**	**2**
PSO4	**2**	**2**	**2**	**3**	**3**
PSO5	**2**	**2**	**3**	**3**	**2**
PSO6	**2**	**2**	**2**	**3**	**3**
PSO7	**2**	**2**	**2**	**3**	**3**
PSO8	**2**	**2**	**2**	**2**	**3**
PSO9	**2**	**2**	**2**	**2**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit I **[12 Hours]**

Terpenoids and Carotenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.

Structure determination and synthesis of the following representative molecules: Menthol, α-Terpeneol, Santonin, Abietic acid and ß-amyrin**.** Biosynthesis of Terpenoids

Unit II **[13 Hours]**

Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, classification based on nitrogen heterocyclic ring and role of alkaloids in plants.

Structure, synthesis and biosynthesis of the following representative molecules: Nicotine, Atropine, Quinine and Morphine.

Unit III **[12 Hours]**

Steroids: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of cholesterol, bile acids, testosterone, progesterone. Biosynthesis of steroids.

Unit IV **[12 Hours]**

Plant Pigments: Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Quercetin, Myrcetin, Diadzein, Cyanidin and Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

Suggested reading

1. Natural products: Chemistry and Biological Significance, J. Mann; R. S. Davidson; J. B. Hobbs; D. V. Banthrope ; J. B. Harborne, Longman publication.
2. Organic Chemistry, Vol 2, I. L. Finar, ELBS.
3. Stereoselective Synthesis: A practrical Approach, M. Nogradi, VCH
4. Rodd's Chemistry of Carbin compounds, Ed. S. Coffey, Elsevier
5. Chemistry, Biological and Phrmacological Properties of Medicinal Plants from the Americas, Ed. K. Hostettmann; M. P. Gupta; A. Marston, Harwood Academic Publishers.
6. Introduction to Flavonoids, B.A.Bohm,Harwood Academic Publishers
7. Chemistry of natural products, S.V. Bhat; B. A. Nagasampagi; M. Sivakumar.
8. Biosynthesis of Natural products, P.Manitto, Ellis Horwood publishers.
9. Natural products from plants, P.B. Kaufman; L. J. Creke; S. Warber; J. A. Dupe; H. L. Brielmann, CRC publication.
10. New Trends in Natural Product Chemistry, Att-ur-Rahman and M.I.Choudhary, Harwood Academic Publisherrs
11. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Terpenoids, Myrcetin, Diadzein, Isolation, nicotine, caffeine

SEMESTER III
SEMESTER III
PAPER CODE: MCHCCO-302 **PAPER TITLE: ORGANIC SYNTHESIS-I**
Total Credits: 03, Total Lectures: 50

Objectives: The core course Organic Synthesis-I is designed to understand the synthetic applications of various reagents, rearrangements and reaction mechanism. The course is imbued with different reagents used for the chemical conversions in organic synthesis including organometallic reagents, oxidising agents and reducing agents. Also, the concept of rearrangement, classification of rearrangements and varous popular rearrangement reactions are also included in this course.

Course Learning Objectives:

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

CLO 1. Recapitulate the concepts of organometallic chemistry, different oxidative & reductive processes and rearrangements. (Cognitive level: Recapitulate)

CLO 2. Understand the basics of organometallic reagents their preparations, properties & reactivity; comprehend metallocenes and non-bezenoid aromatics- general considerations, synthesis and reactions of some representative compounds; leran about the controlled/regioselective oxidation/reductions; understand the concept of rearrangement and general mechanistic considerations *viz.*- nature of migration, migratory aptitude, memory effects and the classification of rearrangements based on nature of the migrating group (Anionotropic/cationotropic rearrangements) and migratory terminus. (Cognitive level: Understand)

CLO 3. Learn and understand the applications of organometallic reagents in organic synthesis along with their mechanistic details; oxidations of hydrocarbons- (alkenes, aromatic rings, saturated C-H groups), alcohols, diols, aldehydes, ketones, ketals, amines, hydrazines & sulphides; reductions of Hydrocarbons (alkenes, alkynes and aromatic rings), carbonyl compounds (Aldehydes, ketones, acids and their derivatives), epoxides, nitro, nitroso, azo & oximes; heterogeneous & homogeneous catalysis & hydrogenolysis and the detailed study of various rearrangements including pinacol-pinacolone, Wagner Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert Synthesis, Neber, Beckmann, Hofman, Curtius, Schmidt, Baeyer Villiger, Shapiro reaction. (Cognitive level: Learn and understand)

CLO 4. Understand and formulate the mechanisms of various popular organic name reactions including Grignard reaction, Oxymercuration, Reformatsky reaction, Simmons-Smithreaction, Barbier allylation, Wilkinson's catalyst, coss-coupling reactions (trans-metalation reactions) including Suzuki Coupling, Heck coupling, Sonogashira coupling, Stille coupling, Negishi Coupling, Lindlars catalyst, Birch reduction, Clemmenson reduction, Wolf Kishner reduction, hydroboration reactions etc.;

involved by various organometallic reagents, oxidising agents and reducing agents. (Cognitive level: Understand and formulate)

CLO 5. Apply different organometallic/oxidising/reducing agents in organic synthesis. (Cognitive level: Apply)

CLO 6. Analyze and develop some new reactions based on the knowledge gained from this course. (Cognitive level: Analyze)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO1.	**3**	**3**	**2**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**	**3**
PSO1	**3**	**3**	**2**	**2**	**2**	**2**
PSO2	**3**	**3**	**2**	**2**	**2**	**2**
PSO3	**3**	**3**	**3**	**2**	**2**	**2**
PSO4	**2**	**2**	**2**	**3**	**3**	**3**
PSO5	**2**	**2**	**3**	**3**	**2**	**2**
PSO6	**2**	**2**	**2**	**3**	**3**	**3**
PSO7	**2**	**2**	**2**	**3**	**3**	**3**
PSO8	**2**	**2**	**2**	**2**	**3**	**3**
PSO9	**2**	**2**	**2**	**2**	**3**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit – I **[13 Hours]**

Organometallic Reagents: Principle, preparations, properties and applications of the following in the organic synthesis with mechanistic details. (2 hrs)

Group I and II Metal Organic compounds: Li, Mg, Hg, Cd & Zn compounds. (5 hrs)

Transition metals: Cu, Pd, Ni, Fe, Co and Rh compounds. (4 hrs)

Metallocenes and non-bezenoid aromatics- general considerations, synthesis and reactions of some representative compounds (2 hrs)

Unit – II **[12 Hours]**

Oxidation: Introduction, different oxidative processes. Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and unactivated). alcohols, diols, aldehydes, ketones, and ketals, amines, hydrazines, sulphides. Oxidizing agents- Jones reagent, LTA, HIO_4, Peracids, $KMnO_4$, OsO_4, SeO_2, Ruthenium tetraoxide, Iodobenzenediacetate and Thallium (III) nitrate.

Unit – III **[12 Hours]**

Reduction: Introduction, different reductive processes, Hydrocarbons- alkenes, alkynes and aromatic rings. Carbonyl compounds: Aldehydes, ketones, acids and their derivatives. Epoxides, nitro, nitroso, azo and oxime groups, Hydrogenolysis, Reducing agents – H_2/metal, Wilkinson catalyst, Lindlars catalyst, LAH, $NaBH_4$, Birch, Clemmenson Wolf Kishner and B_2H_6 reductions.

Unit – IV **[13 Hours]**

Rearrangements: General mechanistic considerations- nature of migration, migratory aptitude, memory effects.

A detailed study of the following rearrangements: Pinacol-pinacolone, Wagner Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert Synthesis, Neber, Beckmann, Hofman, Curtius, Schmidt, Baeyer Villiger, Shapiro reaction.

Books recommended

1. Modern Synthetic reactions, W.A.Benjamin, H.O. House
2. Some Modern Methods of Organic Synthesis, W. Caruthers Cambridge University Press
3. Advanced Organic Chemistry, Reaction Mechanism and structure, Jerry March, John Viley
4. Principles of Organic Synthesis, R. O.C Norman and J.M. Coxon, Blackie Academic and Professional
5. Advanced Organic Chemistry Part B, F.A. Carey, R. J. Sundberg, Plenum Press
6. Rodd's Chemistry of Carbon compounds, Ed. S. Coffey, Elesvier.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning.
  - Class Tests, Worksheets.
  - Assignments, projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Organometallic Reagents, Metallocenes, non-bezenoid aromatics, Oxidations, Reductions, Rearrangements.

SEMESTER III
PAPER CODE: MCHCCO-303 PAPER TITLE: PHOTOCHEMISTRY AND PERICYCLIC REACTIONS
Total Credits: 6 Total Lectures: 50

Objectives: The course explains the mechanism of concerted reactions in the ground and photo-excited states. Students shall also gain knowledge about various photophysical and photo-chemical processes involved in photochemistry

Course Learning Objectives:

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

CLO 1. Understand the reactions of molecules in their photo-excited states. **[Cognitive level: Remember and understand]**

CLO 2. Understand the fundamentals of reactions with a concerted mechanism **[Cognitive level: Remember and understand]**

CLO 3. Apply the understanding of the reaction mechanisms and reactivity concepts for synthesizing compounds in pure form **[Cognitive level: Apply and evaluate]**

CLO 4. To investigate the factors influencing the enantioselectivity of a reaction **[Cognitive level: Analyze]**

CLO 5. Use the fundamental reactivity concepts to bring about multi-step chemical transformations in the laboratory **[Cognitive level: Apply and evaluate]**

CLO 6. Synthesize molecules using these principles and strategies for making enantioenriched compounds. [**Cognitive level: Create**]

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	3	3	2	2	2
PLO2.	3	3	2	2	2
PLO3.	3	3	2	2	2
PLO4.	2	3	3	2	2
PLO5.	2	2	3	3	2
PLO6.	2	2	2	3	3
PLO7.	2	2	2	3	3
PSO1	3	3	2	2	2
PSO2	3	3	2	2	2
PSO3	3	3	3	2	2
PSO4	2	2	2	3	3
PSO5	2	2	3	3	2
PSO6	2	2	2	3	3
PSO7	2	2	2	3	3
PSO8	2	2	2	2	3
PSO9	2	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure:

Unit I **[12 Hours]**

Photochemical reactions: Interaction of electromagnetic radiation with matter, types of excitation, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

Determination of reaction mechanism: Classification, rate constants and life times of reactive energy states-determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions- photo-dissociation, gas-phase photolysis.

Unit II **[13 Hours]**

Photochemistry of alkenes: Intramolecular reactions of the olefinic bond- geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes.

Photochemistry of Carbonyl compounds: Intramolecular reactions of carbonyl compounds-saturated, cyclic and acyclic, β,γ-unsaturated and α, β-unsaturated compounds, Cyclohexadienones. Intermolecular cycloaddition reactions-dimerisations and oxetane formation

Unit III **[12 Hours]**

Photochemistry of aromatic compounds: Isomerisations, additions and substitutions

Miscellaneous photochemical reactions: Photo-Fries reaction, Singlet molecular oxygen reactions, photochemical formation of smog. Photodegradation of polymers, Photochemisty of vision

Unit IV: **[13 hours]**

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

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

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

Suggested reading

1. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern.
2. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
3. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
4. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill.
5. Photochemistry, R.P. Kundall and A. Gilbert, Thomson Nelson.
6. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
7. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.

Teaching Learning Process:

- The teaching Learning Process for the course is student-centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning

- Class Tests, Worksheets
- Presentations, group discussions, assignments and projects to enhance critical thinking skills and personality

- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Quantum yield, Cycloaddition, PMO, Diels alder

SEMESTER III
PAPER CODE: MCHCCO-309 **PAPER TITLE: LAB COURSE**
Total Credits: 10 Total Lectures: 100

Objectives: The lab course is designed to strengthen the basic and fundamental concepts of organic chemistry and apply them to carry out multi-step chemical transformations with the main focus on applying green/sustainable chemistry approach towards planning and doing experiments.

Course Learning Objectives:

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

C.L.O 1. Understand the fundamental reactivity concepts to identify and analyze reaction mechanisms including Free Radical Substitution, Electrophilic Addition, and Electrophilic Aromatic Substitution [**Cognitive level: Remember and understand]**

C.L.O 2. Apply the understanding of organic reaction mechanisms and reactivity concepts for separation/ purification of compounds [**Cognitive level: Analyze]**

C.L.O 3. Use the fundamental reactivity concepts to bring about multi-step chemical transformations in the laboratory **[Cognitive level: Apply and evaluate]**

C.L.O 4. Synthesize molecules using green/sustainable chemistry approaches [**Cognitive level: Create**]

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	**3**	**3**	**2**	**2**	**2**
PLO2.	**3**	**3**	**2**	**2**	**2**
PLO3.	**3**	**3**	**2**	**2**	**2**
PLO4.	**2**	**3**	**3**	**2**	**2**
PLO5.	**2**	**2**	**3**	**3**	**2**
PLO6.	**2**	**2**	**2**	**3**	**3**
PLO7.	**2**	**2**	**2**	**3**	**3**
CLO 1.	**3**	**3**	**2**	**2**	**2**
CLO 2.	**3**	**3**	**2**	**2**	**2**
CLO 3.	**3**	**3**	**3**	**2**	**2**
CLO 4.	**2**	**2**	**2**	**3**	**3**
CLO 5.	**2**	**2**	**3**	**3**	**2**
CLO 6.	**2**	**2**	**2**	**3**	**3**
CLO 7.	**2**	**2**	**2**	**3**	**3**
CLO 8.	**2**	**2**	**2**	**2**	**3**
CLO 9.	**2**	**2**	**2**	**2**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure:

The experiments shall be covered from the following practical course:

1. Benzaldehyde → Benzalacetophenone → Epoxide
2. 4-Nitro toluene → 4-Nitro benzoic acid → 4-Amino benzoic acid
3. Resorcinol → 4-methyl-7-hydroxy coumarin → 4-Methyl-7-acetoxy coumarin
4. Cyclohexanone → Phenyl hydrazone → 1,2,3,4-Tetrahydrocarbazole
5. Hydroquinone → Hydroquinone diacetate → 1,2,4-Triacetoxy benzene
6. Acetanilide → p-Acetamidobenzene sulphonyl chloride → P. Acetamidobenzene sulphonamide
7. p-Amino phenol → p-Acetyl amino phenol → p-Ethoxy acetanilide
8. Hippuric acid → Azalactone → 4-Benzylidene 2-phenyl oxazol-5-one
9. p-Cresol → p-Cresyl benzoate → 2-Hydroxy-5-methyl benzophenone
10. Phthalimide → N-Benzylphthalimide → Benzylamine
11. o-Nitroaniline → o-Phenylene diamine → Benzimidazole
12. Phthalic acid → Phthalimide → Anthranilic acid →o-Chlorobenzoic acid
13. Benzyl cyanide→ p-Nitrobenzyl cyanide→p-Nitro phenyl acetic acid
14. Hydroquinone → Hydroquinone diacetate → 2,5-Dihydroxy acetopheneone
15. Cyclohexanone→ Enamine→2-Acetyl cyclohexanone
16. α-Pinene→ Disiamyl borane→Pinanol
17. Base catalyzed aldol condensation using $LiOH.H_2O$ as a Catalyst.
18. Bromination of trans-stilbene using sodium bromide and sodium bromate
19. [4+2] cycloaddition reaction in aqueous medium at room temperature
20. Benzil Benzilic acid rearrangement under solvent-free condition
21. Thiamine hydrochloride catalyzed synthesis of benzoin from benzaldehyde
22. Clay catalyzed solid-state synthesis of 7-hydroxy-4-methyl coumarin
23. Eco-friendly nitration of phenols and its derivatives using Calcium nitrate
24. Bromination of acetanilide using ceric ammonium nitrate in aqueous medium
25. Green approach for preparation of benzopinacolone from bezopinacol using iodine catalyst
26. Preparation of 1, 1-bis-2-naphthol under grinding at room temperature.
27. Solvent free aldol condensation between 3,4-dimethoxybenzaldehyde and 1-indanone
28. Solvent-free quantitative solid-phase synthesis of azomethines from substituted anilines and substituted benzaldehydes.
29. Sucrose to ethyl alcohol (Baker's yeast)
30. Asymmetric reduction of EAA by using Baker's yeast
31. Alkylation of diethyl malonate with an alkyl chloride using microwaves.
32. Alkylation of diethyl malonate or ethyl acetoacetate with an alkyl halide using phase transfer catalyst.

Suggested reading

1. Practical Physical Chemistry, Findley, Kitchener, Longman, 1977.
2. Advanced Practical Physical Chemistry, Yadav, Goel Pub, 1994.
3. Experiments in Physical Chemistry, 5th ed., Schoemaker et al., MGH, 1989.
4. Vogel's qualitative Inorganic Analysis; 6th edn; Svehla (Longman, 1994

5. The physical Chemistry of Inorganic Qualititative analysis; Kuriacose, Rajaram (Tata MGH, 1972)
6. Vogel's Textbook of Quantitative chemical Analysis; 5th edn; Jeffery, Bassett; (ELBS, 1989)
7. Quantitative Analysis; 6th edn; Day, Underwood (Printice Hall, 1993).
8. Chromatographic Methods; 3rd ed; Stock & Rice (Chapman & Hall, 1980).
2. Analytical Chemistry; 5th ed; D. Christian (Wiley)
3. Comprehensive Practical Organic Chemistry, V.K. Ahluwalia, Renu Agarwal (University Press India Ltd.-2000)
4. Organic Laboratory techniques, Donald C Pavia, Gary M Lampman.
5. Experimental Organic Chemistry John C Gilgert, Stephen F Martin.(SCP)
6. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets
  - Assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Solvent free, Clay catalyzed, Baker's yeast, Thiamine hydrochloride

Semester - IV

SEMESTER IV
PAPER CODE: MCHCCO-401 **PAPER TITLE: CHEMISTRY OF NATURAL PRODUCTS -II**
Total Credits: 03 Total Lectures: 50

Objectives: The course along with course **MCHCCO-301** acquaints the learner with different classes of natural products, their biosynthetic pathways and their general reactivity apart from important techniques of identifying and characterizing them

Course Learning Objectives:

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

C.L.O 1. Get an insight into more of natural products chemistry. (Learn and Understand)

C.L.O 2. Gain knowledge about the occurrence, distribution, different methods of isolation, and general methods of structure determination of phenolic compounds, prostaglandins, fatty acids and biopolymers (Learn and Understand)

C.L.O 3. Understand the properties of natural products, their structure-activity relationship, and their pharmacological effects. (Understand)

C.L.O 4. Identify and analyze the different classes of natural products on the basis of chemical tests (Analyze)

C.L.O 5. Apply modern analytical methods in the structure elucidation of natural products. (Apply and evaluate)

C.L.O 6. Synthesis of different classes of natural products. (Create)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	3	3	2	2	2
PLO2.	3	3	2	2	2
PLO3.	3	3	2	2	2
PLO4.	2	3	3	2	2
PLO5.	2	2	3	3	2
PLO6.	2	2	2	3	3
PLO7.	2	2	2	3	3
PSO1	3	3	2	2	2
PSO2	3	3	2	2	2
PSO3	3	3	3	2	2
PSO4	2	2	2	3	3
PSO5	2	2	3	3	2
PSO6	2	2	2	3	3
PSO7	2	2	2	3	3
PSO8	2	2	2	2	3
PSO9	2	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit I **[12 Hours]**

Prostaglandins: Occurrence, nomenclature, classification, biogeneseis and physiological effects. Synthesis of PGE_2 and PGF_2.

Simple phenolic compounds: Structure and properties of naphthoquinones, anthraquinones, anthranols, anthrones and dianthrones. Coumarins - Classification, simple coumarins and their derivatives, isolation and identification. Tannins – Introduction, classification, hydrolysable tannins, condensed tannins, biological activities of tannins

Unit II **[13 Hours]**

Biopolymers: Classification, structure and properties of amino acids, primary structure of peptides – N-terminal amino acid determination, carboxyl terminal amino acid determination, partial hydrolysis of peptides, cyclic peptides, biologically active peptides, isoelectric points of proteins. classification and properties of proteins, colour reaction of proteins, sequencing of proteins, conformation and structure of proteins- primary, secondary, tertiary and quaternary structure, coagulation and denaturation of proteins

Unit III

Fatty acids: Fatty acids and its reactions, biological importance of fatty acids and lipids, identification and extraction of lipids, even chain and odd chain fatty acids, saturated and unsaturated fats, ketone bodies, fatty acid metabolism, Biosynthesis of fatty acids and triglycerides, Complex Lipids - Glycerophopholipids: Structure and function of (Phosphatic acid, cardiolipin, Phosphatidyl serine, Phosphatidyl ethanolamine, Phosphatidyl Glycerol, Phosphatidylcholine, Phosphatidyl inositol, plasmalogens),Glycosphingolipids: Structure and function of (Sphingosine, ceramides & sphingomyelins, cerebrosides, globosides, gangliosides, sulfatides), biological membranes, properties and function of lipid bilayers.

Unit IV **[13 Hours]**

Carbohydrates: Introduction, Types of naturally occurring sugars: Deoxy-sugars, dihydrosugars, amino sugars, branched chain sugars. classification, nomenclature. Structures of triose, tetrose, pentose, and hexoses. Determination of ring size of aldohexose and aldopentose, Chain lengthening and chain shortening of aldoses. Reactions at the anomeric centre, reactions at the non-anomeric centre. Sugar analysis by enzymatic methods. structure and properties of polysaccharides – cellulose, starch, pectins and mucopolysaccharides- hyaluronic acid and chondroitin. Separation of carbohydrates.

Suggested reading

1. Natural products: Chemistry and Biological Significance, J. Mann; R. S. Davidson; J. B. Hobbs, D. V. Banthrope ; J. B. Harborne, Longman publication.
2. Organic Chemistry, Vol 2, I. L. Finar, ELBS.
3. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers.
4. New Trends in Natural Product Chemistry, Atta-Ur-Rahman; M. I. Choudhary, Harwood Academic Publishers.
5. Bioactive Natural Products, S.J. Cutler; H.J. Cutler, CRC press.
6. Chemistry of natural products, S.V. Bhat; B.A.Nagasampagi; M. Sivakumar, Narosa publications
7. Biosynthesis of Natural products, P. Manitto, Ellis Horwood publishers
8. Natural products from plants, P. B. Kaufman; L. J. Creke; S.Warber; J. A. Dupe, H. L. Brielmann, CRC publication
9. Organic chemistry of natural products, Vol. I, II, G. Chatwal, Himalya Publishing house.
10. Phytochemicals as bioactive agents, W. R. Bidlack; S. T. Omaye; M.S. Meskin; C. K.W. Topharm, Technomic publishers.

11. Drugs of Natural origin: A text book of Pharmacognosy, Gunnar Simuelsson, Swedish pharmaceutical press, Apotekarsocieteten.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Sugars. Fatty acids, anthraquinones, tannins, proteins

SEMESTER IV
PAPER CODE: MCHCCO-402 **PAPER TITLE: ORGANIC SYNTHESIS-II**
Total Credits: 03, Total Lectures: 50

Objectives: The core course Organic Synthesis-I is designed to understand the retrosynthetic analysis of complex organic compounds and depict suitable schemes for their synthesis. The course comprises of basic concepts of disconnection approach; Functional group interconversion (FGI); C-X disconnection, C-C disconnection; Modern Synthetic Methods; Construction of Ring Systems;Construction of Ring Systems; Protecting groups; aromatic heterocycles in organic synthesis and Synthesis of some complex molecules.

Course Learning Objectives:

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

CLO 1. Recapitulate the concepts of direct synthesis of organic compounds, functional group interconversions, protecting groups and some multicomponent reactions. (Cognitive level: Recapitulate)

CLO 2. Understand the basics of disconnection approach including the terminologies used in retrosynthetic analysis *viz* synthons and synthetic equivalents, functional group inter-conversions; the importance of the order of events in organic synthesis; one group C-X and two C-X disconnections, chemoselectivity; reversal of polarity; cyclization reactions and amine synthesis. (Cognitive level: Understand)

CLO 3. Learn and understand one Group C-C Disconnections (Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, Stereoselective synthesis of tri and tetra substituted olefins, use of acetylenes and aliphatic nitro compounds in organic synthesis); two group C-C Disconnections (Diels Alder reaction, 1,3-difunctionalized compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds, Michael addition and Robinson annulation). (Cognitive level: Learn and understand)

CLO 4. Learn about modern Synthetic Methods (Baylis-Hillman reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction. Brook rearrangement; Prins reaction, Bignelli synthesis); Construction of Ring Systems **(**Different approaches towards the synthesis of three, four, five and six-membered rings; photochemical approaches for the synthesis of four membered rings, oxetanes and cyclobutanes. Pauson-Khand reaction, Bergman cyclization); aromatic heterocycles in organic synthesis; Protecting groups: (Principle of protection of alcohol, amine, carbonyl and carboxyl groups) and Synthesis of some complex molecules (Camphor, Longifoline, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A). (Cognitive level: Learn)

CLO 5. Draw the synthetic route for the synthesis of complex molecules by employing disconnection approach. Also apply the multicomponent reactions for the synthesis of molecules of interest based on the knowledge gained from this course. (Cognitive level: Synthesis)

CLO 6. Apply the protection/de-protection approach in organic synthesis including peptide chemistry, carbohydrate chemistry and other chemical transformations based on the knowledge gained from this course. (Cognitive level: Apply)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO-1	3	3	2	2	2	2
PLO-2	3	3	2	2	2	2
PLO-3	3	3	2	2	2	2
PLO-4	2	3	3	2	2	2
PLO-5	2	2	3	3	2	2
PLO-6	2	2	2	3	3	3
PLO-7	2	2	2	3	3	3
PSO-1	3	3	2	2	2	2
PSO-2	3	3	2	2	2	2
PSO-3	3	3	3	2	2	2
PSO-4	2	2	2	3	3	3
PSO-5	2	2	3	3	2	2
PSO-6	2	2	2	3	3	3
PSO-7	2	2	2	3	3	3
PSO-8	2	2	2	2	3	3
PSO-9	2	2	2	2	3	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit – I **[12 Hours]**

Disconnection Approach: An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two C-X disconnections, chemoselectivity, reversal of polarity, cyclization reactions, amine synthesis.

Unit – II **[12 Hours]**

One Group C-C Disconnections: Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, Stereoselective synthesis of tri and tetra substituted olefins, use of acetylenes and aliphatic nitro compounds in organic synthesis.

Two group C-C Disconnections: Diels Alder reaction, 1,3-difunctionalized compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds, Michael addition and Robinson annulation.

Unit – III: **[13 Hours]**

Modern Synthetic Methods: Baylis-Hillman reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction. Brook rearrangement; Prins reaction, Bignelli synthesis.

Construction of Ring Systems: Different approaches towards the synthesis of three, four, five and six-membered rings; photochemical approaches for the synthesis of four membered rings, oxetanes and cyclobutanes. Pauson-Khand reaction, Bergman cyclization; aromatic heterocycles in organic syntheisis.

Protecting groups: Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

Unit – IV **[12 Hours]**

Synthesis of some complex molecules: Camphor, Longifoline, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A.

Books recommended

1. Designing Organic Synthesis, S. Warren, Wiley
2. Organic Synthesis – Concept, Methods and Starting Materials, J.Fuhrhop and G. Penzillin, Verlage VCH
3. Modern Synthetic reactions, W.A.Benjamin, H.O. House
4. Some Modern Methods of Organic Synthesis, W. Caruthers Cambridge University Press
5. Advanced Organic Chemistry, Reaction Mechanism and structure, Jerry March, John Viley
6. Principles of Organic Synthesis, R. O.C Norman and J.M. Coxon, Blackie Academic and Professional
7. Advanced Organic Chemistry Part B, F.A. Carey, R. J. Sundberg, Plenum Press.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning.
  - Class Tests, Worksheets.
  - Assignments, projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Disconnection Approach, functional group inter-conversions, C-X disconnections, C-C disconnections, Modern Synthetic Methods, Multi-component reactions, Construction of Ring Systems, Protecting groups, Synthesis of some complex molecules.

SEMESTER IV
PAPER CODE: MCHCCO-403 PAPER TITLE: HETEROCYCLIC CHEMISTRY
Total Credits: 6 Total Lectures: 50

Objectives: The course deals with heterocyclic chemistry in a broad perspective. Emphasis is given to the most important heterocyclic systems, such as pyridines, quinolines, isoquinolines, pyrroles, furanes, thiophenes, indoles, pyrimidines, purines, imidazoles, aziridines and oxiranes. For each group, ring synthesis, chemical properties and characteristic reactions will be discussed. Aromaticity applied to heterocyclic compounds, general methods for ring synthesis (by a number of cyclisation and cycloadditon reactions) as well as different systems for nomenclature will be presented.

Course Learning Objectives:

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

CLO 1. Have a theoretical understanding of structure, reactivity and importance of heterocyclic chemistry [**Cognitive level: Remember and understand]**

CLO 2. The student will get familiar with specific properties and different systems of nomenclature [**Cognitive level: Remember and understand]**

CLO 3. Understand general methods for ring synthesis [**Cognitive level:** U**nderstand]**

CLO 4. Application of such methods for the preparation of specific groups of heterocyclic systems. **[Cognitive level: Analyze and apply]**

CLO 5. Apply the understanding of organic reaction mechanisms and fundamental reactivity concepts to bring about chemical transformations in the laboratory. **[Cognitive level: Apply and evaluate]**

CLO 6. Synthesize molecules of medicinal and commercial importance **[Cognitive level: Create]**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	3	3	2	2	2
PLO2.	3	3	2	2	2
PLO3.	3	3	2	2	2
PLO4.	2	3	3	2	2
PLO5.	2	2	3	3	2
PLO6.	2	2	2	3	3
PLO7.	2	2	2	3	3
PSO 1.	3	3	2	2	2
PSO 2.	3	3	2	2	2
PSO 3.	3	3	3	2	2
PSO 4.	2	2	2	3	3
PSO 5.	2	2	3	3	2
PSO 6.	2	2	2	3	3
PSO 7.	2	2	2	3	3
PSO 8.	2	2	2	2	3
PSO 9.	2	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure:

Unit – I **[12 Hours]**

Nomenclature of Heterocycles: Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles.

Aromatic Heterocycles: General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in ^{1}H NMR-spectra, empirical resonance energy, delocalization energy and dewar resonance energy, diamagnetic susceptibility exaltations).

Heteroaromatic reactivity and tautomerism in aromatic heterocycles.

Non-aromatic Heterocycles: Strain – bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction. Stereo-electronic effects- anomeric and related effects. Attractive interactions- hydrogen bonding and intermolecular nucleophilic- electrophilic interactions.

Unit – II **[13 Hours]**

Small ring heterocycles: Three-membered and four-membered heterocycles- synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes.

Benzo-fused five-membered heterocycles: Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes.

Unit – III **[12 Hours]**

Six-membered heterocycles: With one heteroatom; Synthesis and reactions of pyryllum salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridones. Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones.

With two or more heteroatoms: Synthesis and reactions of diazines, triazines, tetrazines and thiazines.

Unit – IV **[12 Hours]**

Seven and large- membered heterocycles: Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines.

Heterocyclic Systems Containing P, As, Sb and B: Heterocyclic rings containing phosphorus: introduction, nomenclature, synthesis and characteristics of 5- and 6-membered ring systems-phosphorinanes, phosphorines, phospholanes and phospholels.

Heterocyclic rings containing As and Sb: introduction, synthesis and characteristics of 5-and 6-membered ring systems. Heterocyclic rings containing B: introduction, synthesis, reactivity and spectral characteristics of 3-, 5- and 6-membered ring systems.

Suggested reading

1. Heterocyclic Chemistry Vol. 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag.
2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
3. Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F. Smith, Champman and Hall.
4. Heterocyclic Chemistry, T.L Gilchrist, Longman Scietific Technical.
5. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.
6. An Introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley.
7. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon Press.

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets
  - Assignments, projects, to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Diazines, heterocycles, Aromatic heterocycles, benzo fused heterocycles

SEMESTER IV
PAPER CODE: MCHCCO-409 PAPER TITLE: PROJECT
Total Credits: 10

Objectives: The purpose of this course is to engage students in active learning and to develop their analytical thinking and problem-solving abilities under the guidance of a mentor. This course will instruct students how to carry out scientific research so that they can go on to get professional training or venture into research and development in any field of chemistry

Course Learning Outcomes (CLOs)

On completing this course, the students should be able to…

CLO 1: Think critically, plan and carry out a research project independently [**Cognitive level: apply**]
CLO 2: Gather, analyze and execute data in the right manner [**Cognitive level: analyze]**
CLO 3: Acquire proficiency in handling instruments **[Cognitive level: Understand]**
CLO 4: Enhance scientific writing skill **[Cognitive level: create**]

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4
PLO1.	3	3	2	2
PLO2.	3	3	2	2
PLO3.	3	3	2	2
PLO4.	2	3	3	2
PLO5.	2	2	3	3
PLO6.	2	2	2	3
PLO7.	2	2	2	3
PSO 1.	3	3	2	2
PSO 2.	3	3	2	2
PSO 3.	3	3	3	2
PSO 4.	2	2	2	3
PSO 5.	2	2	3	3
PSO 6.	2	2	2	3
PSO 7.	2	2	2	3
PSO 8.	2	2	2	2
PSO 9.	2	2	2	2

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

The project shall comprise of the following three components *viz* Part A of 100, Part B of 50 and Part C of 50 marks each given as under.

Part A:
Each student will undertake a project work in the Department of Chemistry under the supervision of a faculty member who will assign a topic of current/general interest under the overall supervision of Head of Department. The student shall consult literature/internet and collect the relevant material. After the completion of the experiment(s), each student has to submit a project report by the deadline fixed for the same purpose.

Part B:
Each student will make a presentation of the work carried out on the assigned topic followed by viva voce on the date and time fixed for the purpose.

Part C:
Each student will be continuously evaluated for his performance in execution of his or her project work during the entire semester by the supervisor assigned by the department for him to supervise the project work
Teaching – Learning Strategies

Learning by doing is the major teaching-learning strategy for realizing the objectives envisaged in work related to research project.

Assessment methods

There will be periodic assessment of the progress of research work carried out under the mentorship of a faculty member.

Discipline centric elective courses

SEMESTER III
PAPER CODE: MCHDCE-304 **PAPER TITLE: MEDICINAL CHEMISTRY**
Total Credits: 3 Total Lectures: 50

Objectives: This course will provide an in-depth look at how novel, pharmacologically active molecules are designed to treat human diseases. An overview of modern medicinal chemistry, from first principles of drug action to design and development of potential therapeutics, will be presented. The action and behavior of pharmaceutical compounds and the relationship between their structure and their chemical and therapeutic properties, and therefore, the chemical considerations in drug design will be explored. Structure activity relationships will be explored through case studies. Methods of drug discovery will be investigated, including the development of drugs from natural products, computer modeling and rational drug design.

Course Learning objectives

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

CLO 1: Explain the Drugs used for various infectious diseases caused by pathogens. Describe the structure activity relation of some important class of drugs and mechanism of action of the drugs (Understand and Explain)

CLO 2: Describe synthesis of medicinally important drug. Explain Therapeutic uses of drugs and Specific side effect of 'Drug Substances' and physico chemical properties related to QSAR (Learn and correlate)

CLO 3: Describe various approaches and designing of drug molecules including prodrug and Combinatorial chemistry. (Understand and assimilate)

CLO 4: Explain the Classification of antitubercular drugs, antiviral drugs and urinary antiinfective agents with examples and structures (Understand)

CLO 5: Discuss the structural activity relationship of drugs and developing idea of rational drug designing based on mechanism of action of a drug. (Correlate and Develop)

CLO 6: Access the physicochemical parameters related QSAR and explain various methods to calculate partition co-efficient. Describe Hanch analysis, Hammett and tafts constant with their relations in explaining the therapeutic index. (Development)

Mapping of CLOs with PLOs and PSOs

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
PLO1	3	3	3	2	2	2
PLO2	2	3	3	3	2	2
PLO3	1	2	3	3	3	2
PLO4	1	1	2	3	3	3
PLO5	1	1	1	2	3	3
PLO6	1	1	1	1	2	3
PLO7	1	1	1	1	1	3
PSO1	3	3	3	2	2	2
PSO2	2	3	3	3	2	2
PSO3	2	2	3	3	3	2
PSO4	2	2	2	3	3	2
PSO5	2	2	2	2	3	2
PSO6	2	2	2	2	2	3
PSO7	1	2	2	2	2	3
PSO8	1	1	2	2	2	3
PSO9	1	1	1	2	2	3

Course structure

Unit – I **[14 Hours]**

Drug Design: Development of New Drug, Procedures followed in drug design, Concepts of lead compounds and lead modification: a)Identification of active part: The pharmacophore b) Functional group modification, c) Structure-activity relationship d) Structure modification to increase potency and the therapeutic index: Homologation; Chain branching; Ring-chain transformation; Bioisosterism, Structural Modification to increase oral Bioactivity: Electronic Effect, The Hammet equation, Lipophilicity effects, concepts of prodrugs, soft drugs and drug delivery systems. Theories of drug activity – occupancy theory, rate theory, induced fit theory Concept of drug receptors – elementary treatment of drug-receptor interactions; Physicochemical parameters – lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials; Factors affecting modes of drug administration, absorption, metabolism and elimination; Significance of drug meta-bolism in medicinal chemistry. Various stages of drug discovery viz., design, synthesis, *in vitro/in vivo* screening, toxicology, ADME studies, clinical studies phases.

The commercial synthetic procedures, classification, mechanism of action, uses and structure activity relationship for selected drugs as included under units II, III and IV shall be covered.

Unit – II **[12 Hours]**

(a) **Antibiotics**
Penicillin, Cephalosporins, Tetracyclines, Macrolides, Streptomycin, Chloramphenicol and Quinolones.

(b) **Sulpha drugs**
Sulphanilamide, Sulphathiazole, Sulphadiazine and Sulphaacetamide

(c) **Antimalarials**
Chloroquine phosphate, Primaquine and Mefloquine

(d) **Antifungal Agents**
Ketoconazole, Griseofulvin

(e) **Antihelmintics**
Albendazole, Mebendezole

Unit – III **[12 Hours]**

(a) **Anti- tubercular**
Isoniazid, Rifampicin, Pyrazinamide, and Ethambutol

(b) **Anti-neoplastics**
Melphalan, Chlorambucil, Cisplatin

(c) **Anti-amoebics**
Emetine, Metronidazole and Tinidazole

(d) **Sedative hynotics**
Pentabarbitone, Allobarbitone

(e) **Anticonvulsants**
Phenytoin, Trimethadione

Unit – IV **[12 Hours]**

(a) **Cardiovascular drugs**
Beta blockers – Clonidine and Methyl Dopa
ACE inhibitor – Captopril

(b) **Non-steroidal anti-inflammatory agents**
Indomethacin, Ibuprofen, Aspirin

(c) **Hypoglycemic agents**
Insulin, Tolbutamide

(d) **Local Anesthetics**
Lignocaine, Procaine

(e) **General anesthetics**
Cyclopropane, Halothane, Thiopental sodium

1. Introduction to Medicinal Chemistry, A Gringuage,Wiley-VCH
2. Wilson and Gisvold's Textbook of organic medicinal and pharmaceutical chemistry, Edited by Robert F. Doerge.
3. Burgers Medicinal Chemistry and Drug Discovery Vol-1, Ed. M.E. Wolff, John Wiley and Sons
4. Principles of Medicinal Chemistry by W.O. Foye. Varghese publishing house Mumbai
5. The pharmacological basis of therapeutics, L.S. Goodman, A. Gilman
6. The organic Chemistry of drug synthesis, D Lednicer. L.A. mitscher
7. Medicinal Chemistry by D. Sriram, P. Yogeeswari Published by Dorling Kindersely (India) Pvt. Ltd. Patpargang, New Delhi
8. Introduction to Medicinal Chemistry, A Gringuage, Wiley-VCH
9. An Introduction to Drug Design, S.S. Pandeya and J.R. Dimmock, New Age International.
10. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
11. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.

Teaching Learning Process:

1. The teaching Learning Progression for the course is student centric
2. Intelligent collaboration of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

Assessment Methods:

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

Keywords:

Drug and Medicine, Physicochemical descriptors, Target and Ligand, Lock and Key model, Anti-microbials, Auto-immune, Resistance.

SEMESTER III
PAPER CODE: MCHDCE-305 PAPER TITLE: CATALYSIS AND GREEN CHEMISTRY
Total Credits: 3 Total Lectures: 50

Objectives: Course is designed to impart knowledge about 12 principal of Chemistry and their application in day-to-day life. The core course Green Chemistry is designed to strengthen the basic and fundamental concepts of sustainabledevelopment which involves reduction in waste generation and better atom economy by producing harmless product.

Course Learning Objectives:

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

- **C.L.O 1.** Understand and explain the different twelve principal of Green Chemistry. (Cognitive level: Remember and Understand)
- **C.L.O 2.** Learn and understand many concepts of atom economy, (Cognitive level: Understand and analyse)
- **C.L.O 3.** Solving many waste generation problem by new concepts of Super critical fluids, ionic liquids etc. (Cognitive level: Understand and analyse)
- **C.L.O 4.** Designing safer method of organic synthesis using microwave and biocatalyst. (Cognitive level: Understand and analyse)
- **C.L.O 5.** Application of green chemistry in daily life like using safer solvents in dry cleaning. (Cognitive level: apply)
- **C.L.O 6.** Concept of sustainable development. (Cognitive level: apply)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO1.	3	3	3	2	2	2
PLO2.	3	3	3	2	2	2
PLO3.	2	3	3	2	2	2
PLO4.	2	3	3	3	2	2
PLO5.	2	2	2	2	3	3
PLO6.	2	2	2	2	2	3
PLO7.	2	2	2	2	2	3
PLO1.	3	3	3	2	2	2
PLO2.	3	3	3	2	2	2
PLO3.	3	3	3	2	2	2
PLO4.	2	2	2	3	3	3
PLO5.	2	2	3	3	2	2
PLO6.	2	2	2	3	3	2
PLO7.	2	2	2	2	3	3
PLO8.	2	2	2	2	2	3
PLO9.	2	2	2	2	2	3

Course structure

Unit-I **[10Hours]**

Principles of Sustainable and Green Chemistry: Basic principles of green chemistry, Tools of green chemistry, Green Chemistry and Industry, Waste Minimisation and Atom Economy, Some inherently atom economic and uneconomic reactions. Reduction of materials use- Concept of sustainability, Reduction of non-renewable raw material use, Catalytic solutions, Process intensification, Reduction of energy requirement, Some energy efficiency improvements, Alternative energy sources, Reduction of risk and hazard, Inherently safe design, Alternative solvents.

Unit-II **[15 Hours]**

Solvent free Chemistry: Organic Synthesis in Solid State; Alternative Solvents: Water; Supercritical fluids- Supercritical CO_2 as a replacement for organic solvents, Extraction of Natural Products; Multiphase and single phase processes using supercritical CO_2 as a reaction and separation phase, Simultaneous use of supercritical CO_2 as reaction medium and reagent; Renewable Solvents; Ionic Liquids- reactions in acidic and neutral ionic liquids; Fluorous Solvents- biphase concept, synthesis of fluorous compounds, fluorous extraction, fluorous synthesis, fluorous reagents; Liquid Polymers: PEG, PPG, Poly(dimethylsiloxane)

Unit III **[15 Hours]**

Sonochemistry in Chemical Synthesis: Sonochemical reactions: Substitution, addition, oxidations, reductions, esterification, hydrolysis, and coupling reactions, Ultrasonic preparation of micro- and nanostructured materials.

Approaches to Microwave-assisted Organic Chemistry: solvent-free methods, methods with solvents, Metal-catalysed Processes, Enzymatic Processes.

Photochemistry: Photons as Clean Reagents, Reduced usage of reagents, Lower reaction temperatures, Control of selectivity

Unit IV **[10 Hours]**

Catalysis: Solid Acid Catalysts- Zeolite-based solid acid catalysts, Heteropolyacid-based solid acid Catalysts, Sulfated zirconia, Ion-exchange resins, Acidic and pillared clays; Micelle-templated Silicas as Catalysts: Catalytic Applications, Oxidation catalysis, Base catalysis (other than oxidations), Enantioselective catalysis

Books recommended

1. Green Chemistry- Theory and Practice by Paul T. Anastas, John C. Warner, Oxford University press, 1998.
2. Methods and reagents for green chemistry-An Introduction, Pietro Tundo, Alvise Perosa, Fulvio Zecchini, John Wiley & Sons, Inc., 2007
3. Green Solvents For Chemistry-Perspectives and Practice by William M. Nelson, Oxford University Press, Inc. 2003
4. Alternative Solvents for Green Chemistry by Francesca M. Kerton, The Royal Society of Chemistry, 2009
5. Green chemistry and the ten commandments of sustainability by Stanley E. Manahan, ChemChar Research, Inc., 2006

SEMESTER III
PAPER CODE: MCHDCE-306 PAPER TITLE: ADVANCED METHODS OF CHEMICAL ANALYSIS
Total Credits: 3 Total Lectures: 50

Objectives: The primary objective of this course is to acquire basic concepts about principles, process and instrumentation of various analytical techniques viz Atomic spectroscopy, electroanalytical methods, electrophoretic techniques, centrifugation and X-ray methods as well as learn to apply them for data interpretation. This would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.

Course Learning Outcomes (CLOs)

CLO 1 Get an insight into the basic and fundamental concepts of Atomic spectroscopic techniques, electroanalytical methods, electrophoretic techniques, centrifugation and X-ray methods. **[Cognitive level: Remember and Understand]**

CLO 2 To understand the use and applications of these techniques for solving analytical problems **[Cognitive level: Remember and Understand]**

CLO 3 To analyse the data acquired by using these techniques. **[Cognitive level: Analyze and evaluate]**

CLO 4 To apply the concepts to solve real life analytical problems **[Cognitive level: Apply]**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4
PLO1.	3	3	3	2
PLO2.	3	3	2	2
PLO3.	2	3	3	3
PLO4.	2	3	2	2
PLO5.	3	3	3	3
PLO6.	2	2	2	3
PLO7.	2	2	2	3
PSO1	3	3	3	2
PSO2	3	3	2	2
PSO3	3	3	2	2
PSO4	2	2	3	3
PSO5	3	2	2	2
PSO6	2	2	3	2
PSO7	2	2	3	3
PSO8	2	2	2	3
PSO9	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit I **[12 Hours]**

Atomic Spectroscopy: Introduction, basic principle of atomic absorption, methodology, sample preparation, flame, electrothermal atomization, hydride methods, principle of atomic emission spectroscopy. Instrumentation of ICP spectrometer-sequential and simultaneous elemental analysis

Unit II **[13 Hours]**

Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit III **[12 Hours]**

Electrophoretic Techniques: Principle, equipment and process, Agarose gel electrophoresis, horizontal and vertical gel electrophoresis, electrophoresis techniques, Isoelectric focusing, capillary electrophoresis and application of electrophoresis in analysing macromolecules.

Centrifugation: Introduction, Basic Principle of sedimentation, Types, care and safety of centrifuges, Preparative centrifugation, Analytical centrifugation, Ultracentrifugation

Unit IV **[13 Hours]**

X-ray Methods: Production of x-ray spectra, absorption of x-rays, analysis by absorption, absorption edge analysis, absorption apparatus, determination of molecular structure by X-ray diffraction, crystal morphology, lattice and unit cells, kinds, space lattice, planes or faces of cubic systems, labeling the planes, the Miller indices, spacing of the planes, X-ray crystallography, the powder methods, the rotating crystal methods.

Books recommended

1. Instrumental Methods of Analysis, 7th edn., H.H. Willard, L.L. Merritt, Jr., J.A. Dean and F.A. Settle, Jr., C.B.S. Publishers and Distributor, 1986, Tata McGraw (New Delhi)
2. Instrumental methods of Chemical Analysis, 5th edn., G.W. Ewig.
3. Instrumental Methods of Analysis by G.D. Christian and C.N. Reilly
4. Principle of Instrumental Methods of Analysis; D.A. Stoog, D.M. West and F.J. Holler, Sounders College Publishing New York, 2001.
5. Ionic Equilibria in Analytical Chemistry; Freiser and Fernando
6. Chemical Analysis, H.A. Laitinen

Teaching Learning Process:

1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and educational animations for showing the kinetics (consecutive mechanism) using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

Assessment Methods:

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

Keywords:

Electroanalytical methods, electrophoretic techniques, centrifugation and X-ray methods

SEMESTER IV
PAPER CODE: MCHDCE-404 **PAPER TITLE: POLYMER CHEMISTRY**
Total Credits: 3 Total Lectures: 50

Objective: The course Polymer Chemistry is designed to encompass the basic to elaborated understanding of stability and reactivity of polymers around as material and basic necessity in today's world scenario. The role of various factors on the fate of the polymerisation. The course is instilled with the application of polymers, thermodynamic and kinetic aspects of polymerisation conditions used in explanations of obtained results.

Course learning objectives

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

CLO 1 Understand the role of various factors responsible in Structure, classification and nomenclature of polymers. Learns and understand the Physical properties of the Amorphous and crystalline arrangements of polymers-Amorphous state, Elasticity, Crystallinity, thermal transitions, effect of chemical structure on physical properties, solubility of polymers, molecular weight and molecular weight distribution, Steric arrangement in various physical and chemical properties like stability, polarity, acidity, basicity etc. of different organic species of both neutral and charged in nature. (Know and Apprehend)

CLO 2 Learn and Understand kinetics of polymerisation-anionic, cationic and free radical its influence in homo-, hetero-and co-polymerisation. Also realize the difference between the ring opening polymerisation and its effect of Degree of polymerisation. (Learn and explore)

CLO 3 To Know Characterization of polymers: molecular weight and molecular distribution: molecular weight determination by osmometry, light scattering, viscometry and gel permeation chromatography and techniques associated with end group analysis. (Apply and analyse)

CLO 4 Assessment of techniques TGA, DSC and DMA with suitable examples. (Learn, utilize and Analyse)

CLO 5 Examine and integrate the processing methods with the basic principles associated (Examine and Investigate)

CLO 6 Predict and apply the methods associated with the field, develop intuitive approaches inspired from their interest to develop interdisciplinary approaches. (develop)

Mapping of CLOs with PLOs

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
PLO1	3	3	3	2	2	2
PLO2	2	3	3	3	2	2
PLO3	1	2	3	3	3	2
PLO4	1	1	2	3	3	3
PLO5	1	1	1	2	3	3
PLO6	1	1	1	1	2	3
PLO7	1	1	1	1	1	3
PSO1	3	3	3	2	2	1
PSO2	3	3	3	3	2	1
PSO3	2	3	3	3	2	2
PSO4	3	3	3	3	2	2
PSO5	2	2	2	3	3	3
PSO6	2	2	2	2	3	3
PSO7	1	2	2	2	3	3
PSO8	1	1	1	2	3	3
PSO9	1	1	1	1	3	3

Course structure

Unit I **[14 Hours]**

Structure, classification and nomenclature of polymers: Physical properties of the polymers- Amorphous and crystalline arrangements-Amorphous state, Elasticity, Crystallinity, thermal transitions, effect of chemical structure on physical properties, solubility of polymers, molecular weight and molecular weight distribution, Steric arrangement

Unit II **[12 Hours]**

Chain growth polymerization: Free radical polymerization process, kinetics, initiators, efficiency of initiators, chain growth, steric, polar and resonance effects in the propagation reaction, termination of polymeric reactions, chain transfer, control of molecular weight, inhibitors and retarders, Effect of reaction medium and temperature on chain polymerization, ceiling temperature, Auto-acceleration Ionic chain growth polymerization: Cationic polymerization- Kinetics, Initiators, propagation, and termination reactions. Anionic polymerization- Kinetics, Initiators, propagation, and termination reactions. Coordinated anionic polymerization, Heterogenous and homogenous Ziegler Natta catalysts

Step growth polymerization: Mechanism, kinetics and statistics of linear step growth polymerization, Carother's equation, Co-polymerisation- mechanisms, kinetics, Copolymer equation, monomer reactivity ratio, graft polymerization and block copolymerization. Ring opening polymerization, kinetics, cationic, anionic and hydrolytic polymerization of lactams

Unit III **[12 Hours]**

Characterization of polymers: molecular weight and molecular distribution: molecular weight determination by osmometry, light scattering, viscometry and gel permeation chromatography, end group analysis, TGA, DSC and DMA with suitable examples. Polymer processing: classification of polymer processing, extrusion and extuders, calendering, film blowing, injection moulding, blow moulding, vacuum forming, rotational, transfer and compression moulding, fibre spinning, polymer additives.

Unit IV **[12 Hours]**

Industrial Polymers: Polyolefins: polyethylene, polypropylene PMMA, polyacrylonitrile, polyamides-nylons. polyethylene terephthalate, polycarbonates, polydienes- natural rubber, polyisoprenes, rubbers derived from butadiene, cellulose and related polymers phenol-formaldehyde polymers, aminopolymers-urea formaldehyde resin, polyurethranes.

Textbook of Polymer science,

1. F. W. Billmeyer, Jonn Wiley and Sons publication.
2. Principles of polymer chemistry: A. Ravve, Kluwer Academic publications
3. Polymer Chemistry: An Introduction, S. P. Malcolm, Oxford University Press
4. Polymer Science and technology, J. R. Fried, Prentice – Hall.
5. Principles of polymer systems, F. Rodriguez; C.Cohen; C. K. Ober; L. A. Archer, Taylor & Francis
6. Introduction to polymers, R.J. Young; P.A. Lovell, Netron Thornes publications
7. Polymeric materials: Structure - Properties – Applications, W. E., Gottfried,
8. Hanser Gardner Publications
9. Principles of polymer science, P.Bahadur; N.V. Shastri, Narosa publishing house
10. Introductory polymer chemistry, G. Mishra, New age Int. publication.
11. Polymer chemistry and physics of modern materials, J. M. H Cowie; Stancly, Thomas publication.

Teaching Learning Process:

1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and educational animations for showing the kinetics (consecutive mechanism) using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

Assessment Methods:

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

Keywords:

Intermedates based classification, Polymerisation, Processing polymers, Physicochemical aspects and techniques, Solvent effect and intiators

SEMESTER IV
PAPER CODE: MCHDCE-405 **PAPER TITLE: BIOORGANIC AND BIOINORGANIC CHEMISTRY**
Total Credits: 3 Total Lectures: 50

Objective: The course Bioorganic and Bioinorganic Chemistry is designed to encompass the basic to an elaborated understanding of simple to complex mechanisms of various biological functions and enzyme activation and inactivation phenomenon in basic life processes. The role of various factors cascades of biologically important motifs. The course also covers the importance of elements in the hysteresis of the living system and also entails their cruciality in modern drug design.

Course learning objectives
On completion of this course the students will be able to:

CLO 1 Comprehend the Enzymes in various chemical and biological catalysis and remarkable properties of enzymes like catalytic power, specificity, regulation, and kinetic aspects. Apply Enzymes in Organic Synthesis. (Learn and understand)
CLO 2 Understand and remember the mechanisms behind biocatalyst in biological and chemical systems. Also apprehend their role in Energy transfer, transport and electron-based changes in cascadic process for the sustenance of life. (Remember and Explain)
CLO 3 Characterization and Evaluation of biological functions and understand Essential and trace metals in biological system, classification and application; Deficiency/ excess and treatment; antagonistic effect of elements and its remedy (Apply)
CLO 4 Develop insight and correlation among various mechanism of enzymes and responsibility of various biological molecules. (Development)
CLO 5 Examine and integrate the organic and inorganic balances and their cooperative behaviours with the basic principles associated (Examine)
CLO 6 Predict and apply the methods associated with the various similar phenomenon, advance intuitive approaches to utilize and develop novel and potent intra- and interdisciplinary approaches. (Apply)

Mapping of CLOs with PLOs

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
PLO1	3	3	3	2	2	2
PLO2	2	3	3	3	2	2
PLO3	1	2	3	3	3	2
PLO4	1	1	2	3	3	3
PLO5	1	1	1	2	3	3
PLO6	1	1	1	1	2	3
PLO7	1	1	1	1	1	3
PSO1	3	3	3	2	2	1
PSO2	3	3	3	3	2	1
PSO3	2	3	3	3	2	2
PSO4	3	3	3	3	2	2
PSO5	2	2	2	3	3	3
PSO6	2	2	2	2	3	3
PSO7	1	2	2	2	3	3
PSO8	1	1	1	2	3	3
PSO9	1	1	1	1	3	3

Course structure

Unit – I **[14 Hours]**

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 hyporthesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver- Burk plots, reversible and irreversible inhibition. Mechanism of Enzyme Action: Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease,lysozyme and carboxypeptidase A. Enzyme Applications in Organic Synthesis: Introduction, optical rotation and enantiomeric excess, general aspect of enzyme catalysts, hydrolysis and formation of C-O bonds, hydrolysis of C-N bond, epoxide and nitrile hydration, oxido-reductases, carbon-carbon bond forming reactions, lyases, immobilization of enzymes/cells, industrial applications of immobilized enzymes and cells.

Unit-II **[12 Hours]**

Kinds of Reactions Catalyzed by Enzymes: Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerization reactions, β-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation. Co-Enzyme Chemistry: Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and Biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD^+, FMN, FAD, lipoic acid, vitamin B12. Mechanisms of reactions catalyzed by the above cofactors.

Unit III: **[12 Hours]**

Metal Ions in Biological Systems: Essential and trace metals in biological system, classification and application; Deficiency/ excess and treatment; antagonistic effect of elements and its remedy.
Na^+/K^+ Pump: Roles of metals ions in biological processes.
Transport and Storage of Dioxygen: Heme proteins and oxygen uptake; structure and function of hemoglobin, myoglobin, oxygen transport in mammals, importance of Fe^{2+} Bohrs effect, Perutz mechanism. hemocyanins and hemerythrin; model synthetic complexes of iron, cobalt and copper; Vaska compound.

Unit IV: **[12 Hours]**

Electron Transfer in Biology: Structure and functions of metalloproteins in electron transport processes –cytochromes and iron-sulphur proteins; synthetic models. Nitrogenase: Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenase model systems.

Books Recommended:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Books.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Inorganic Biochemistry, Vols. I and II. Ed., G.L. Eichhorn, Elsevier.
4. Progress in Inorganic Chemistry, Vols. 18 and 38 ed. J.J. Lippard, Eiley.
5. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag
6. Understanding Enzymes, Trevor Palmer, Prentice Hall
7. Enzyme Chemistry: Impact and Applications, Ed. Collin J. Suckling, Chapman and Hall
8. Enzyme mechanisms, Ed. M.I.Paje, A. Williams, RSC
9. Fundamentals of Enzymology, N.C.Price, L. Strevens, Oxford University Press.

10. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Viley
11. Enzymatic Reaction Mechanisms, C. Walsh, W.H. Freeman
12. Enzymes- Structure and Mechanism, A Fersht, W.H. Freeman
13. Biochemistry: The Chemical Reactions of the Living Cells, D. E. Metzler, Academic Press

Teaching Learning Process:

1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

Assessment Methods:

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

Keywords:
Biocatalyst, Protein-ligand models, Prutz's mechanism, Physicochemical descriptors, intermediate based mechanism classification

SEMESTER IV
PAPER CODE: MCHDCE-406 **PAPER TITLE: Molecular Modelling & Drug Design**
Total Credits: 3 Total Lectures: 50

Objective: The students understand the concepts of drug research according to the in silico approach also known as molecular modelling. The comparison of structure- and target-based drug design. The fundamental understanding of energy profiles and the shape of molecules that reflect the conformational arrangement of drug molecules provides mathematical models for the prediction and design of target-specific drugs. The role of quantum chemical analysis in understanding the possible behavior of a small molecule.

Course Learning obejective:
On completion of this course the students will be able to:

CLO 1 Understand Fundamentals of molecular modeling would be covered with understanding of the coordinate system to begin the 3D assemblies. The development of the potential energy surface towards molecular graphics. Theoretical background of terms and theories used in molecular modeling such as Hartree Fock, DFT and difference from molecular mechanics. Computational limitations of calculating precised and accurate results to that of experimentally obtained results. (Learns and Know)

CLO 2 Learn various structural parameters and conformational aspects of a small molecules and their physical aspects alongwith theories used for their determination insilico. Different approaches of determining the molecular properties and their limitations. Importance of charges, dipoles, multipoles and Force fields and theirs applications from small to macromolecular systems. (Learn and Classify)

CLO 3 Investigation of a reaction and prediction of the transition state using the internal reaction coordinate profiles and methods to determine the energy landscapes of possible associated mechanisms and their validation using simulation methods. Distinguishing between molecular mechanics and dynamics and their abilities to determine the kinetic and thermodynamic properties using energetics and stochastic dynamics. (remember and apply)

CLO 4 Understanding of Monte Carlo, dreiding and steepest descent methods for energy minimization and optimization of molecular ensembles. (understand and correlate)

CLO 5 Investigation of systems involving macromolecules and small molecules using the common protocol of molecular docking. Screening of a large molecular database using virtual screening and application of docking to ligand-based drug design. (Explain and Apply)

CLO 6 Understanding the structures of proteins based on the homology and mutations related to the stability of a protein. Structural similarities using the basics of shapes and structural similarity using the chemical information determined from the chemical compositions such as amino acids in proteins. Challenges and scope of developing a model roughly more efficient to solve the Schrondinger wave equation of complex systems. (Apply and Develop)

Mapping of CLOs with PLOs and PSOs

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
PLO1	3	3	3	2	2	2
PLO2	2	3	3	3	2	2
PLO3	1	2	3	3	3	2
PLO4	1	1	2	3	3	3
PLO5	1	1	1	2	3	3
PLO6	1	1	1	1	2	3
PLO7	1	1	1	1	1	3
PSO1	3	3	3	2	2	2
PSO2	2	3	3	3	2	2
PSO3	2	2	3	3	3	2
PSO4	2	2	2	3	3	2
PSO5	2	2	2	2	3	2
PSO6	2	2	2	2	2	3
PSO7	1	2	2	2	2	3
PSO8	1	1	2	2	2	3
PSO9	1	1	1	2	2	3

Course structure

Unit I **[14 Hours]**

Introduction to Molecular Modelling: Introduction - Useful Concepts in Molecular Modelling : Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

Quantum chemistry: Single- and multiple electron systems. Ab initio-methods, Hartree-Fock equations, gaussian basis sets. Orbitals, calculation of partial charges, practical program usage.

Unit II **[12 Hours]**

Molecular force fields: Bonds, angles, torsions. Electrostatics and van der Waal forces, parameterisation from experiments or quantum chemistry. Effective pair potentials, hydrogen bonds. Computation of molecular properties and limitations, examples of commonly used force fields.

Unit III **[12 Hours]**

Energy landscapes*:* Minimizations, algorithms, normal modes, transition states and reaction pathways. Simulation methods*:* Molecular dynamics, equilibration, thermodynamical properties from simulations, stochastic dynamics, energy conservation. Monte Carlo methods and conformational analysis.

Unit IV **[12 Hours]**

Bioinformatics*:* Sequence analysis, protein structure, homology modeling, 3D structure prediction from sequence, chemo-informatics, combinatorial databases.

Advanced applications*:* Free energy calculations from simulations, free energy of solvation, chemical reactions, molecular docking, modern drug design with simulations and quantum chemistry.

Books Recommended:

1. Leach, A. R. ***Molecular modelling - principles and applications***, 2nd ed., ISBN 0-582-38210-6
2. J.M.Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
3. Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.

Teaching Learning Process:

1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

Assessment Methods:

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

Keywords:

Molecular Modelling, Ab-initio method, Drug-target binding, Quantum mechanics, Newton mechanism, weak forces

Generic Elective Courses

SEMESTER III
PAPER CODE: MCHOE-307 **PAPER TITLE: ENVIRONMENTAL CHEMISTRY**
Total Credits: 03, Total Lectures: 50

Objectives: The open elective course Environmental chemistry is designed to understand the different aspects of environment, factors responsible for pollution and the monitoring& controlling of the pollutants. The course is imbued with the composition of atmosphere, chemical and photochemical reactions taking place in the atmosphere, Air pollutants (including ozone depletion; global warming), water pollutants, industrial pollution, Harmful effects of pollutants on living and non-living species, Analytical methods for monitoring air pollutants; international and national standards; Physical, chemical and biological water quality parameters; their assessment, Water treatment processes, Water table maintenance and harvesting methods.

Course Learning Objectives:

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

CLO 1. Recapitulate the composition of atmosphere, pollution and the pollutants responsible for various types of pollution including air, water, marine and soil pollution (Cognitive level: Recapitulate/ recall).

CLO 2. Understand the chemical and photochemical reaction cycles of C, N, P, S and O. (Cognitive level: Understand).

CLO 3. Learn about air pollutants including CO, SO2, NO_X, CO_2, ozone, CFC; learn about the various photochemical reactions that cause air pollution, the harmful effects of pollutants on living and non-living species, various analytical methods for monitoring air pollutants, learn about physical, chemical and biological water quality parameters, point & non-point sources of Soil/water/air pollution; learn about various water treatment processes including aeration, solid purification nanofiltration, chemical treatments, reverse osmosis and desalination, Understand the water table maintenance & harvesting methods and Identify countless industrial pollutants. (Cognitive level: learn).

CLO 4. Understand about the major global concerns of ozone depletion & global warming in current scenario. (Cognitive level: Understand).

CLO 5. Know about international and national standards of air & water quality, assess the air & water quality and waste disposal management. (Cognitive level: Know about).

CLO 6. Analyse the factors responsible for pollution and figure out the solutions. Analyse and hypothesize the chemical solutions to environmental problems and green protocols of decomposition, biodegradability, better industrial processes. (Cognitive level: analyse).

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO 1.	**3**	**3**	**2**	**2**	**2**	**2**
PLO 2.	**3**	**3**	**2**	**2**	**2**	**2**
PLO 3.	**3**	**3**	**2**	**2**	**2**	**2**
PLO 4.	**2**	**3**	**3**	**2**	**2**	**2**
PLO 5.	**2**	**2**	**3**	**3**	**2**	**2**
PLO 6.	**2**	**2**	**2**	**3**	**3**	**3**
PLO 7.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 1.	**3**	**3**	**2**	**2**	**2**	**2**
PSO 2.	**3**	**3**	**2**	**2**	**2**	**2**
PSO 3.	**3**	**3**	**3**	**2**	**2**	**2**
PSO 4.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 5.	**2**	**2**	**3**	**3**	**2**	**2**
PSO 6.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 7.	**2**	**2**	**2**	**3**	**3**	**3**
PSO 8.	**2**	**2**	**2**	**2**	**3**	**3**
PSO 9.	**2**	**2**	**2**	**2**	**3**	**3**

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure

Unit I **[12 Hours]**

Composition of atmosphere; chemical and photochemical reaction cycles of C, N, P, S and O. Air pollutants - CO, CO_2, ozone, CFC; ozone depletion; global warming (12 hrs)

Unit II **[12 Hours]**

Harmful effects of pollutants on living and non-living species; Analytical methods for monitoring air pollutants; international and national standards.

Unit III **[12 Hours]**

Physical, chemical and biological water quality parameters; their assessment. Water pollution; water pollutants; toxicity aspects; international and national standards; control.

Unit IV **[12 Hours]**

Water treatment processes: aeration, solid purification nanofiltration, chemical treatments, reverse osmosis, desalination. Water table maintenance & harvesting methods.

Industrial pollution: Sugar, drug, paper and pulp sectors, thermal power plants. Disposal of wastes and its management. Chemical solutions to environmental problems, principles of decomposition, biodegradability, better industrial processes. (14 hrs)

Books recommended

1. Environmental Chemistry, **S. E. Manahan, Taylor & Francis Ltd**
2. Basic Concepts of Environmental Chemistry, D.W. Connell, CRC-Press
3. Environmental Chemistry: A Global Perspective, G.W. Vanloon; S. J. Duffy , Oxford Univ Pr (Sd)
4. Introduction To Environmental Chemistry, **J. B. Reid, Blackwell Science Ltd**
5. Chemistry of the Environment, T. G. Spiro; W. M. Stigliani, Prentice Hall publication.
6. Environmental Chemistry, **G. W Duffy; J. Stephen, Oxford Higher Education publication**
7. Environmental Chemistry, C. Baird; M.Cann, W. H. Freeman

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning.
  - Class Tests, Worksheets.
  - Assignments, projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords: Composition of atmosphere, photochemical reaction cycles, Air pollutants, Ozone depletion, Global warming, Harmful effects of pollutants, Analytical methods for monitoring air pollutants, water quality parameters, Water pollution, Water treatment processes, Industrial pollution.

SEMESTER III
PAPER CODE: MCHOE-I-308 **PAPER TITLE: FOOD CHEMISTRY I**
Total Credits: 03, Total Lectures: 50

Objectives: Course is designed to impart knowledge of the different quality attributes of food and their application in day-to-day life. This interdisciplinary course is designed to strengthen the basic and fundamental concepts of food sustainability and safety.

Course Learning Objectives:

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

CLO 1. Understand the different quality attributes of food [**Cognitive level: Remember and understand]**

CLO 2. Remember the national and international food Safety standards and regulations, Understand the principles of food toxicology and methods used in safety evaluation-risk assessments of food toxins [**Cognitive level: Remember and understand]**

CLO 3. Understand the factors affecting food spoilage and apply procedures for identification of the genera and species of microorganisms responsible for the food quality and safety. **[Cognitive level: Understand and analyse]**

CLO 4. Apply the principles and procedures involved in inactivating/killing microorganisms in foods/Hurdle technology **[Cognitive level: Apply]**

CLO 5. Design and develop different methods of food safety **[Cognitive level: Create]**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	3	3	2	2	2
PLO2.	3	3	2	2	2
PLO3.	3	3	2	2	2
PLO4.	2	3	3	2	2
PLO5.	2	2	3	3	2
PLO6.	2	2	2	3	3
PLO7.	2	2	2	3	3
PSO 1.	3	3	2	2	2
PSO 2.	3	3	2	2	2
PSO 3.	3	3	3	2	2
PSO 4.	2	2	2	3	3
PSO 5.	2	2	3	3	2
PSO 6.	2	2	2	3	3
PSO 7.	2	2	2	3	3
PSO 8.	2	2	2	2	3
PSO 9.	2	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure:

Unit I **[12 Hours]**

Food additives I: Introduction, aroma substances-Impact Compounds of Natural Aromas, Threshold Value, Aroma Value, Off-Flavors, Food Taints, Aroma Analysis. Individual Aroma Compounds: Nonenzymatic Reactions, Enzymatic Reactions. Flavour enhancers: Monosodium Glutamate (MSG), **5**_-Nucleotides, Maltol.Sugar substitutes: sweeteners, sweet taste-structural requirements, structure–activity relationships in sweet compounds. Saccharin, Cyclamate, Curculin and Miraculin, Gymnema silvestre Extract, Stevioside, Phyllodulcin, Glycyrrhizin, Dihydrochalcones, Aspartame, Speraspartame, Neotame. Food colours, Antioxidants-Inhibition of lipid peroxidation, antioxidant activity, antioxidants in food, natural antioxidants, synthetic antioxidants, synergists, prooxidative effect. Acids and bases used in food industries.

Unit II **[13 Hours]**

Food additives II: Antimicrobial agents: Benzoic Acid, PHB-Esters, Sorbic Acid , Propionic Acid, Acetic Acid, SO2 and Sulfite, Diethyl (Dimethyl) Pyrocarbonate, Ethylene Oxide, Propylene Oxide, Nitrite, Nitrate Antibiotics, Diphenyl, o-Phenylphenol, Thiabendazole, 2-(4-Thiazolyl) benzimidazole. Emulsifiers: emulsions, emulsifier action, structure and activity, HLB-Value, synthetic emulsifiers-Mono-, diacylglycerides and derivatives, sugar esters, sorbitan fatty acid esters, polyglycerol – polyricinoleate (PGPR), stearyl-2-lactylate. Humectants- polyols 1,2-propanediol, glycerol, mannitol, sorbitol. Thickening agents, gel builders- agar, alginates, carrageenans, gum arabic, gum tragacanth, starch, cellulose- alkyl cellulose, hydroxyalkyl cellulose, Carboxymethyl cellulose, Anticaking agents, Bleaching agents, Propellants, Modified atmospheric packaging, protective gases.

Unit III **[12 Hours]**

Food Microbiology: Microorganisms important in food microbiology; common foodborne bacteria, common genera of foodborne molds, common genera of foodborne yeasts, intrinsic and extrinsic parameters of foods that affect microbial growth, low-temperature food Preservation and characteristics of psychrotrophic microorganisms, high-temperature food preservation and characteristics of thermophilic microorganisms, preservation of foods by drying, indicators of food safety and quality, principles of quality control.

Unit IV **[13 Hours]**

Food Toxicants: Toxic trace elements in food- Arsenic, Mercury, Lead, Cadmium; Veterinary medicines and feed additives - Antibiotics, Anthelmintics, Coccidiostats, Analysis; Polychlorinated biphenyls; Harmful Substances from Thermal Processes-Polycyclic Aromatic Hydrocarbons (PAHs), Furan, Acrylamide; Nitrate, Nitrite, Nitrosamines; Polychlorinated Dibenzodioxins (PCDD) and Dibenzofurans (PCDF); Food-borne illness – bacterial and fungal, Toxic compounds of microbial origin, mycotoxins.

Books recommended

1. Food Chemistry, Belitz ; Gosch, Springer – Verlag Bertin Heiderberg publication.
2. Principles of Human Nutrition, M. Eastwood, Chapman and Hall.
3. Food – The Chemistry of its Components, T.P. Coultate, Royal Soc. Chemistry.
4. Food additives, B. A. Larry; D. P. Michael, Food Science and Technology series (35), Morcel Dekker, Inc.
5. Introduction to food science, R. Parker, Delmar Learning publication.
6. Nutrition Science and application, Smolin L.A, Saunders College Publishing
7. Human Nutrition and dietetics, J.S. Barrow; W.P.T James; Churchill, Livingstone publication

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning.
  - Class Tests, Worksheets.
  - Assignments, projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab.

Keywords:

Additives, preservation, aroma substances, Antimicrobial agents, Toxic trace elements, mycotoxins

SEMESTER IV
PAPER CODE: MCHOE-407 **PAPER TITLE: Chemistry in Nanoscience**
Total Credits: 3 Total Lectures: 50

Objectives: Course will help students to learn about basic concepts of Nanotechnology, Nanomedicine and Nanotoxicology. Students will acquire knowledge about synthesis, stabilization and application of Nanomaterials.

Course Learning Objectives:

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

CLO 1 ClO.1 Understand and explain the difference between Nanotechnology & Nanomedicine. (Cognitive Level: remember and understand)
CLO 2 CLO2 Learn and understand many concepts Nanochemistry (Cognitive Level: understand)
CLO 3 ClO3 Understanding of Drug delivery & Drug Targetting (Cognitive Level: understand)
CLO 4 CLO4 Designing of Nanosymthesis and Nanoformulation (Cognitive Level: Analyze)
CLO 5 CLO5 Application of Nanomaterials in daily life. (Cognitive Level: apply)
CLO 6 CLO6 Biomedical Applications of Nanomaterials. (Cognitive Level: apply)

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6
PLO1.	3	3	3	2	2	2
PLO2.	3	3	3	2	2	2
PLO3.	2	3	3	2	2	2
PLO4.	2	3	3	3	2	2
PLO5.	2	2	2	2	3	3
PLO6.	2	2	2	2	2	3
PLO7.	2	2	2	2	2	3
PLO1.	3	3	3	2	2	2
PLO2.	3	3	3	2	2	2
PLO3.	3	3	3	2	2	2
PLO4.	2	2	2	3	3	3
PLO5.	2	2	3	3	2	2
PLO6.	2	2	2	3	3	2
PLO7.	2	2	2	2	3	3
PLO8.	2	2	2	2	2	3
PLO9.	2	2	2	2	2	3

Course structure

Unit-I **[11 Hours]**

NANOPARTICULATE DRUG-DELIVERYSYSTEMS

Methods of Measurements and characterization of nanomaterials -transmission electron microscopy, scanning electron microscopy, scanning probe techniques (scanning probe microscopy), optical tweezers (single-beam gradient trap). Manufacture of nanomaterials - bottom-up manufacturing, top-down manufacturing

Unit-II **[12 Hours]**

POLYMER-BASED NANOPARTICULATE DRUG-DELIVERY SYSTEMS

Drug-delivery systems - lipid-based colloidal nanodrug-delivery systems, solid–lipid nanoparticle system, nanoparticulate polymeric micelles as drug carriers, polymeric micelles and solubilization of drugs, polymeric micelles and reticuloendothelial system, recent trends in polymeric micelles research. Hydrogel-based nanoparticulate drug-delivery systems - Dendrimer-based drug-delivery systems.

Unit-III **[13 Hours]**

DIVERSE AND EMERGING TRENDS IN NANOTECHNOLOGY APPLICATIONS

Biological analysis and discovery, nanoparticle tagging, nanostructured materials, single-molecule detection, protective nanoparticles against pathogens, nanotubes and cellular manipulation, antibody-coated nanospheres, nanocrystallites, nanohybrids, nanocontainer technology, electrospun nanofibers as drug-delivery systems, future directions.

Unit-IV **[14 Hours]**

ROLE OF NANOTECHNOLOGY IN THE DEVELOPMENT OF NANOMEDICINE

Role of nanotechnology in molecular diagnostics, nanoparticles for molecular diagnostics, gold nanoparticles, quantum dots, magnetic nanoparticles, role of nanotechnology in drug discovery, nanoparticles for drug discovery, use of gold nanoparticles for drug discovery, use of quantum dots for drug discovery

Books recommended

1. Nanoparticulate Drug Delivery System by Michael Deleers
2. Handbook of Nanobook by Gary Wiederrecht
3. Nanoparticles: Synthesis,Stabilization, Passivation, and Functionalization by T. Alan Hatton
4. Polymeric Drug Delivery Systems by James Swarbrick

Teaching Learning Process:

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets
  - Assignments, projects, to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Gold nano particle, quantum dots, drug delivery, nano syntheis

SEMESTER IV
PAPER CODE: MCHOE-II-408 **PAPER TITLE: FOOD CHEMISTRY II**
Total Credits: 03, Total Lectures: 50

Objectives: This interdisciplinary course is designed to strengthen the basic and fundamental concepts of food sustainability and safety. The course aims at educating about, properties, composition, production, processing storage and utilization of various important food products

Course Learning Objectives:

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

C.L.O 1. Understand the Status of dairy in India and world, milk products chemistry, milk microbiology and quality evaluation. **[Cognitive level: Remember and Understand]**

C.L.O 2. Gain insight on processing aspects of milk and other important food products, and learn about new technologies and their applications **[Cognitive level: Analyse and understand]**

C.L.O 3. Do testing of nutraceuticals and testing of milk and other food products **[Cognitive level: Analyse]**

C.L.O 4. Apply the principles of dairy processing to value added milk products development **[Cognitive level: Apply]**

C.L.O 5. Development of functional foods **[Cognitive level: Create]**

Mapping of CLOs with PLOS

	CLO1	CLO 2	CLO 3	CLO 4	CLO 5
PLO1.	3	3	2	2	2
PLO2.	3	3	2	2	2
PLO3.	3	3	2	2	2
PLO4.	2	3	3	2	2
PLO5.	2	2	3	3	2
PLO6.	2	2	2	3	3
PLO7.	2	2	2	3	3
PSO 1.	3	3	2	2	2
PSO 2.	3	3	2	2	2
PSO 3.	3	3	3	2	2
PSO 4.	2	2	2	3	3
PSO 5.	2	2	3	3	2
PSO 6.	2	2	2	3	3
PSO 7.	2	2	2	3	3
PSO 8.	2	2	2	2	3
PSO 9.	2	2	2	2	3

3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.

Course structure:

Unit I **[13 Hours]**

Milk and Dairy products: Physico-chemical properties of milk, composition of milk- Proteins, casein fractions, micelle formation, gel formation, w hey proteins, carbohydrates, lipids, organic acids, minerals, vitamins, enzymes, plasmin, lactoperoxidase, Processing of milk- purification, creaming, heat treatment, homogenization, types of milk.

Milk products: Fermented Milk Products - Sour milk, yogurt; Cream; Butter- Cream separation and treatment, churning, packaging, products derived from butter; ice creams; condensed milk, dehydrated milk products; cheese- curd formation, ripening, processed cheese.

Other products: casein, caseinates and coprecipitates, lactose, whey products- whey powder, partially desugared whey protein concentrates, hydrolyzed whey syrups.

Unit II **[13 Hours]**

Food Products I: Cereals and cereal products: general anatomy, chemical composition, Wheat- individual constituents, milling. Wheat Flour- chemical assays, physical assays, baking tests. Corn, Rice, Rye, Oats, Barley- storage, milling and milling products.

Vegetables and their products: Composition- nitrogen compounds, carbohydrates, lipids, organic acids, phenolic compounds, aroma substances; storage; vegetable products-dehydrated vegetables, canned vegetables, frozen vegetables, pickled vegetables, vegetable Juices, vegetable pastes, vegetable powders.

Sugars and sugar alcohols: Nutritional/physiological properties, sucrose, production of beet sugar, production of cane sugar, other sources for sucrose production, packaging and storage, types of sugar, sugars produced from sucrose, Sugar alcohols-isomaltol , sorbitol, xylitol, mannitol.

Unit III **[12 Hours]**

Food Products II Fruits and their products: Composition- nitrogen compounds, carbohydrates, lipids, organic acids, phenolic compounds, aroma substances, chemical changes during ripening of fruit, ripening as influenced by chemical agents, storage of fruits, fruit products- dried, canned, deep frozen, marmalades, jams and jellies, fruit juices, analysis.

Eggs- Structure, physical properties and composition- Albumen- proteins, lipids, carbohydrates, minerals, vitamins, egg yolk- proteins, lipids, vitamins, storage of eggs, egg products, technically important properties.

Meat- Structure of muscle tissue, muscle tissue composition and function, color of meat, curing, reddening, postmortem changes in muscle, aging of meat, water holding capacity of meat, kinds of meat, meat analysis.

Unit IV **[12 Hours]**

Food Products III: Honey- Production and types, processing, physical properties, composition, storage, utilization, artificial honey.

Coffee- Harvesting and processing, storing and packaging, composition, coffee products- instant coffee, decaffeinated coffee.

Tea- Harvesting and processing, storing and packaging, types, composition.

Cocoa - Harvesting and processing, composition, production of cocoa liquor, production of cocoa powder, chocolate production, storage

Alcoholic beverages- Raw materials, processing, composition, types of beer and wine. Spirits- production, Liquor from wine, fruit, cereals and sugarcane

Salt- Composition, production, salt substitutes

Vinegar- Composition, microbiological production, chemical synthesis,

Books recommended

1. Food Chemistry, Belitz ; Gosch, Springer – Verlag Bertin Heiderberg.
2. Food – The Chemistry of its Components, T.P. Coultate, Royal Soc. Chemistry.
3. Introduction to food science, R. Parker, Delmar Learning.
4. Food Safety and Toxicity, J.de vries, CRC press.
5. Food Analysis – Theory & Practice, S.N. Mahindru, Metropolitan Book Co. Ltd.
6. Fundamentals of cheese science, P. F. Fox; T. P. Guinee, Aspen Publications
7. Food Technology processing and laboratory control, F. Aylward, Agrobios Publications.

Teaching Learning Process:

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Assessment Methods:

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    - Class Tests, Worksheets
    - Assignments, projects, to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

Keywords:

Dairy, Harvesting and processing, storing and packaging, Alcoholic beverages, meat, curing