SCHOOL OF CHEMICAL SCIENCES

MAHATMA GANDHI UNIVERSITY

CURRICULUM STRUCTURE AND SYLLABI

(BASED ON OUTCOME BASED EDUCATION)

For the Programmes,

- **M. Sc. CHEMISTRY (Inorganic Chemistry)**
- **M. Sc. CHEMISTRY (Organic Chemistry)**
- **M. Sc. CHEMISTRY (Physical Chemistry)**
- **M. Sc. CHEMISTRY (Polymer Chemistry)**

(Under the CSS Regulations 2021 of Mahatma Gandhi University
w.e.f**. 2021** Admission Onwards)

PREFACE

I am happy to present the revised curricula and syllabi of the following M.Sc. Chemistry programmes of the School of Chemical Sciences according to the Outcome Based Education (OBE) concept (with effect from 2021 admission onwards) for the favour of approval by the Faculty and Academic Council of the University.

1. M.Sc. Chemistry (Inorganic Chemistry)
2. M.Sc. Chemistry (Organic Chemistry)
3. M.Sc. Chemistry (Physical Chemistry)
4. M.Sc. Chemistry (Polymer Chemistry)

The Board of Studies has restructured the curriculum as per the OBE concept. OBE is an educational approach that bases each part of the educational system concerning the goals set for the students. OBE aims to equip the students (learners) with the knowledge and competency orientations required for achieving their goals when they depart the institution. Further OBE empowers students to choose what they would like to study and how they would like to study it. The teaching methodologies and the evaluation system are also modified at par with the outcome-based approach. The programme Specific Outcomes (PSOs) and the Course Outcomes (COs) are also presented in the syllabus. The PSOs and the COs are well correlated in the syllabus of each course.

The draft curricula and syllabi for all the M.Sc. Chemistry programmes were discussed in a very effective manner in the Board of Studies of the School of Chemical Sciences. The Board of Studies has also modified the scheme, curricula and syllabi for the four M.Sc. programmes in conformity with the Revised CSS Regulations 2020 by the Mahatma Gandhi University to suit the Credit and Semester System. The content of the syllabus has been modified significantly (around 20 % of the total content from the previous syllabus especially by adding new courses such as industrial chemistry (third semester) and advanced courses in Inorganic, Organic, Physical and Polymer Chemistry, in the fourth semester. Another salient feature of the revised curriculum is the inclusion of a new open course named Science and Society.

The Board of Studies (BOS) feels that appreciable updating could be done in keeping up with the current developments and trends in chemistry education.

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Prof. K. S. Devaky

(Chairman, Board of Studies of School of Chemical Sciences)

Members of the Board of Studies of School of Chemical Sciences

(*vide* UO No. 3246/1/2017/Election Dated 06/08/2020)

1. Prof. K. S. Devaky (Chairman)
2. Prof. Suresh Mathew
3. Prof. Beena Mathew
4. Prof. Raju Francis
5. Prof. G.Anilkumar
6. Dr. S. Anas
7. Dr. Chithra Mohan
8. Dr. Subila K. B
9. Dr. Manoj N (External Expert)
10. Dr. Sreerag Gopi (External Expert)

Mahatma Gandhi University

Vision

"Mahatma Gandhi University envisions to excel in the field of higher education and cater to the scholastic and developmental needs of the individual, through the continuous creation of critical knowledge base for the society's sustained and inclusive growth."

Mission

- To conduct and support undergraduate, postgraduate, and research-level programmes of quality in different disciplines.
- To foster teaching, research and extension activities for the creation of new knowledge for the development of society.
- To help in the creation and development of manpower that would provide intellectual leadership to the community.
- To provide skilled manpower to the professional, industrial, and service sectors in the country to meet global demands.
- To help promote the cultural heritage of the nation and preserve the environmental sustainability and quality of life.
- To cater to the holistic development of the region through academic leadership.

School of Chemical Sciences

Vision

- Quality education in chemical sciences for the creation of a vibrant and inclusive society.

Mission

- Generation, preservation and dissemination of knowledge in the frontier areas of chemical science.
- Equip the students to build up a scientific career and contribute towards national development.
- Foster collaboration with leading research institutions in knowledge production.
- Inculcate among students' human values with global competence

Preamble

Outcome Based Education (OBE) w.e.f. the Academic Year 2021-22
SCHOOL OF CHEMICAL SCIENCES
Mahatma Gandhi University

Introduction

A high-priority task in the context of education in India is the improvement of the quality of higher education for equipping young people with skills relevant to global and national standards and enhancing the opportunities for social mobility. Mahatma Gandhi University has initiated an Outcome Based Education (OBE) system for enhancing the employability of graduates through curriculum reforms grounded on a learning outcomes-based curriculum framework, upgrading academic resources and the learning environment.

Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. The fundamental premise underlying the learning outcomes-based approach to curriculum development is that higher education qualifications are awarded based on demonstrated achievement of outcomes, expressed in terms of knowledge, understanding, skills, attitudes and values. Outcomes provide the basis for effective interaction among the various stakeholders. It is results-oriented thinking and is the opposite of input-based education where the emphasis is on the educational process.

Outcome Based Education (OBE) process

OBE is a comprehensive approach to organise and operate a curriculum that is focused on and defined by the successful demonstrations of learning sought from each learner. The term means focusing and organising everything in an education system around “what is essential for all learners to be able to do successfully at the end of their learning experiences”. OBE is an approach to education in which decisions about the curriculum and instruction are driven by the exit learning outcomes that the students should display at the end of a programme or a course. By the end of the educational experience, each student should have achieved the outcomes.

Benefits of OBE

The OBE Framework is a paradigm shift from the traditional education system into the OBE system where there is a greater focus on programme and course outcomes. It guarantees that curriculum, teaching and learning strategies and assessment tools are continuously enhanced through a continuous improvement process. All decisions including those related to curriculum, delivery of instruction, and assessment are based on the best way to achieve the predetermined outcomes. Traditionally, educators have measured learning in terms of standardised tests. In contrast, outcome-based education defines learning as what students can demonstrate that they know.

- More directed & coherent curriculum.
- Graduates will be more "relevant" to the industry & other stakeholders (well-rounded Graduates).
- Continuous Quality Improvement is in place.
- OBE shifts from measuring input and process to include measuring the output (outcome)

Learning Outcomes based Curriculum Framework (LOCF) for Post Graduate Programmes: IQAC MG University

One of the main objectives of OBE is to ensure continuous improvement of programmes in terms of maintaining the relevance in the curriculum as well as responding to the requirements of the stakeholders. An OBE system has been proposed and to be implemented at various departments of Mahatma Gandhi University from 2020-21 academic year onwards, as a quality-assurance approach to improve teaching and learning outcomes and processes. This OBE plan incorporates the "outcomes assessment" process that to be followed in the departments. OBE should be a key driver of curriculum management in all the departments of the University. Therefore, as envisaged by the IQAC of Mahatma Gandhi University, an OBE curricular framework has been proposed for the Masters programmes of the School of Chemical Sciences w.e.f. the academic year 2020- 2021 which is presented hereafter. In this regard, we have framed the syllabus in accordance with the programme outcomes of Mahatma Gandhi University as listed below.

Programme Outcomes (PO) of Mahatma Gandhi University

PO 1: Critical Thinking and Analytical Reasoning

Capability to analyse, evaluate and interpret evidence, arguments, claims and beliefs based on empirical evidence; reflect relevant implications to reality; formulate logical arguments; critically evaluate practices, policies, and theories to develop knowledge and understanding; able to envisage the reflective thought to the implication on the society.

PO 2: **Scientific Reasoning and Problem-Solving**

Ability to analyse, discuss, interpret and draw conclusions from quantitative/qualitative data and experimental evidence; and critically evaluate ideas, evidence, and experiences from an unprejudiced and reasoned perspective; capacity to extrapolate from what one has learned and apply their competencies to solve problems and contextualise into research and apply one's learning to real-life situations.

PO 3: Multidisciplinary/Interdisciplinary/Transdisciplinary Approach

Acquire an interdisciplinary/multidisciplinary/transdisciplinary knowledge base as a consequence of the learning they engage with their programme of study; develop a collaborative-multidisciplinary/interdisciplinary/transdisciplinary-approach for formulating constructive arguments and rational analysis for achieving common goals and objectives.

PO 4: Communication Skills

Ability to reflect and express thoughts and ideas effectively in a verbal and nonverbal way; Communicate with others using appropriate channel; confidently share one's views and express herself/himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information clearly and concisely and articulate in a specific context of communication.

PO 5: Leadership Skills

Ability to work effectively and lead respectfully with diverse teams; setting direction, formulating a goal, building a team who can help achieve the goal, motivating and inspiring team members to engage with that goal, and using management skills to guide people to the right destination, smoothly and efficiently.

PO 6: Social Consciousness and Responsibility

Ability to contemplate the impact of research findings on conventional practices, and a clear understanding of responsibility towards societal needs and reaching the targets for attaining inclusive and sustainable development.

PO 7: Equity, Inclusiveness, and Sustainability

Appreciate equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity, secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity, managing diversity and use of an inclusive approach to the extent possible.

PO 8: Moral and Ethical Reasoning

Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work and living as a dignified person in the society.

PO 9: Networking and Collaboration

Acquire skills to be able to collaborate and network with scholars in educational institutions, professional organizations, research organizations, and individuals in India and abroad.

PO 10: Lifelong Learning

Ability to acquire knowledge and skills, including "learning how to learn", that is necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives and adapting to changing trades and demands of the work place through knowledge/skill development/reskilling.

Eligibility for Admission

BSc. degree in Chemistry (Mathematics as one of the Subsidiaries) with not less than 50% marks in Part III. Only a pass in the qualifying exam is required for SC/ST candidates. Those who are awaiting final semester results of the qualifying exam can also apply provided that they should produce the mark list of qualifying examination before the commencement of their M Sc. first semester examination.

Admission Procedure

Candidates have to appear for the Common Admission Test (CAT) conducted by MG University in April/ May of every year. The questions will be of objective multiple-choice type. Any other conditions prescribed by MG University from time to time in this regard will be applicable. Relaxation of marks and Reservation of seats under SC/ST is based on University/ Government Rules. Admission may be based on the written test alone or written test and

interview or on the basis of the marks obtained in the qualifying examinations as well as the marks obtained in the written test, the interview and/or the group discussion conducted by the respective Schools as decided by the Faculty Council of Schools/Centres/Institutes from time to time. The Rank list for admission will be prepared as per university guidelines. While preparing the rank list, if there are same index marks for more than one candidate, they will be ranked based on actual marks obtained in the qualifying exam (CAT). Even after this, if there is a tie; they will be ranked on the basis of date of birth that is the older person is to be ranked higher. The duration of the MSc (Full-time) programme at the School of Chemical Sciences is of two years consisting of four semesters. Each semester shall comprise a minimum of 18 instructional weeks and will be adjusted to have at least 90 working days. Continuous Internal Assessment based evaluation during the course period and End Semester Examination at the end of each semester shall be conducted.

Course Registration

A student must register for the required number of courses as per the specific curriculum of a programme, after the commencement of class of that semester. Each student shall have a course card for each semester, wherein the title of the courses and corresponding course codes are entered and signed by the student, the faculty member offering the course and countersigned by the Director/Head of the Department. Based on this, a consolidated statement of courses to which registration is granted for the semester is to be prepared by the department. This statement must be signed by the Director/Head of the department and has to be submitted to the CSS section of the examination branch of the University within 20 days after the commencement of class of each semester.

Evaluation

There shall be continuous internal assessment as well as end semester examinations for all the courses. Evaluation of the first and third semester courses shall be done by the respective faculty members of SCS. End semester Examinations of the second and fourth semesters shall be conducted based on the question paper set by External Examiners. There will be a double valuation of answer scripts of the end semester examination of the even semesters of the four M Sc. programmes. One valuation shall be conducted by External Examiner and the other by the faculty member who taught the course. External Examiner should be a competent person in the specified subject from other Universities/Institutes. A

panel of External Examiners is prepared based on the recommendation of the Faculty Council of SCS and approval of the same by the Vice Chancellor.

Indirect Grading is employed for the evaluation of courses. The performance of a student in each course is evaluated in terms of the percentage of marks converted to grade points. Students have to secure a minimum attendance of 75% to appear for the end semester examination. A separate minimum of 40% of marks is required in the Continuous Assessment (CA) as well as the End semester examination for a pass in a course. Students who fail to obtain a minimum of 40% mark in the Continuous Assessment can request the faculty council for a chance to improve their marks. The faculty council may permit the student to secure the minimum mark in CA, by conducting written Tests. However, only one chance will be given to improve CA marks.

Process of Evaluation

The internal assessment will be a continuous assessment (CA) that accounts for 40% of the evaluation in both theory and practical. The end semester examination will account for the remaining 60% of the evaluation.

End-Semester Examination: The end semester examination will account for 60% of the evaluation. The evaluation of the end-semester examination of the first and third semesters shall be done by the faculty who taught the course. Evaluation of the second and fourth semester courses based on questions set by external experts shall be evaluated by two examiners; one, the external (as far as possible the question paper setter shall evaluate the examination paper as well) and the other, the internal examiner, the faculty who taught course. The Head of the School will make necessary arrangements for the evaluation of the answer scripts. The project report/dissertation shall be evaluated by two examiners, one the faculty member of the school and the other an external examiner to be decided by the HOD from a panel recommended by the faculty council and approved by the Vice Chancellor. The comprehensive viva-voce will be carried out along with the project evaluation.

Continuous Assessment (CA): The student's participation and classroom performance as well as the feedback received from tests, tutorials, assignments and term papers shall form the basis for continuous assessment (CA). It accounts for 40% of the evaluation in both theory and practical. This assessment shall be based on a predetermined transparent system

involving periodic written tests, assignments and seminars in respect of theory courses and based on tests, lab skills, records/viva and attendance in respect of practical courses.

The percentage of marks assigned to various components for internal evaluation is as follows

a. Theory

Sl. No	Components	Percentage of marks
1.	Test Papers (2)	50
2.	Assignment / Debates/Book review	25
3.	Seminar/ Presentation of Case study	25

b. Practicals

Sl. No	Components	Percentage of marks
1.	Lab skill	25
2.	Observation and recording results	30
3.	Punctuality and neatness	25
4.	Viva-voce	20

Test Papers: For each course, there shall be at least three class tests during a semester. The average of the marks obtained in the best two tests will be counted as the internal test component of CAS. Valued answer scripts shall be made available to the students for perusal within 10 working days from the date of the tests.

Assignments: Each student shall be required to do 2 assignments for each course. Assignments after valuation must be returned to the students. The teacher shall define the expected quality of the above in terms of structure, content, presentation and the like, and inform the same to the students. Punctuality in the submission of assignments/records is to be given a weightage in the internal evaluation.

Seminar: Every student shall deliver one seminar as an internal component of every course and must be evaluated by the respective course teacher in terms of structure, content, presentation and interaction. The soft and hard copies of the seminar report are to be submitted to the teacher in charge.

Results of Continuous Assessment: The results of the CA counter-signed by the Head of the school/Centre shall be displayed on the notice board 5 days before the end semester examinations. The marks awarded for various components of the CA shall not be rounded off if it has a decimal part. The total marks of the CA shall be rounded off to the nearest whole

number. Relevant records of continuous assessment (CA) must be kept in the department and that must be made available for verification.

Project Work: There shall be a project to be undertaken by all students. The dissertation entails field work, lab work, report writing, presentation and viva voce. The class hours allotted for project work may be clustered into a single slot so that students can do their work at parent school or other institutions for a continuous period. However, appropriate changes can be made by the faculty council in this regard. Project/dissertation shall be carried out under the supervision of a teacher in the parent School/Centre/Institute or other research institutes or industrial establishment or university departments if they permit the students to do so, after getting permission from the Department Head. In such cases, one of the teachers from the schools/centres/institutes would be the co-supervisor/internal guide and an expert from the industry/ research organization concerned shall act as supervisor/ external guide.

Process of evaluation of project work in the fourth semester: The evaluation of the project in the fourth semester will be done by an external examiner, based on the work done by the student, content, presentation of the project work and a viva-voce. A panel of External Examiners is prepared based on the recommendation of the Faculty Council of SCS and approval of the same by the Vice Chancellor.

There is no provision for improving the continuous assessment/ final evaluation of the project.

Pattern of Question papers for the End- Semester Written Examination

The question papers set for the end-semester written examination will have three sections and carry 60 marks as detailed below:

Section A - Fifteen short answer questions, a minimum of one from each Unit. Students will have to answer any twelve. Each question will carry three marks (Total 36 marks).

Section B - Six short essay questions, a minimum of one from each Unit. Students will have to answer any four. Each question will carry 6 marks (Total 24 marks).

Both the sections will contain questions covering all the cognitive levels Remembering/ Understanding/Applying/Analysing/ Evaluating and Creating. There will be questions of higher levels of learning for at least 10 marks.

The End Semester Examination (ESE) will be of three hours duration and carry 60 marks. The ESE for the core and elective courses shall be conducted based on the following pattern of the question paper.

Section	Cognitive level	Choice and marks of questions	Question specification	Total Marks	Alignment with Course outcomes (COs)
Section A	Remembering/ Understanding/ Applying/ Evaluating	12 out of 15 questions; 3 marks each	Minimum one question from each unit	36	Aligned with COs
Section B	Applying/ Analysing/ Evaluating/ Creating	4 out of 7 questions; 6 marks each	minimum one question from each unit	24	Aligned with COs
Section A+ B				60	

The **cognitive levels** of questions in the End Semester Examinations are summarised as:

- **Lower levels** of learning (Remembering/Understanding/Applying): 30 to 40%
- **Higher Levels** of Learning (Analysing/Evaluating/Creating): 60 to 70%

The **difficulty levels** of questions in the End Semester Examinations are categorised as Low, Medium and High. The percentage of questions in each level of difficulty are given below:

- Low: 20 to 30%
- Moderate: 55 to 65%
- High: 15 to 25%

Grading System

The performance of a student in each course is evaluated in terms of a percentage of 21 marks with a provision for conversion to grade points. The grading system followed is that of relative grading on a ten-point scale. The following table indicates the performance range and the relative value of the grades (grade points) on the scale.

Performance range and the Relative value of the Grades (Grade points)

Range of % of	Letter Grade	Performance	Grade points
95 to ≤ 100	O	Outstanding	10
85 to ≤ 95	A PLUS	Excellent	9
75 to ≤ 85	A ONLY	Very Good	8

65 to ≤ 75	B PLUS	Good	7
55 to ≤ 65	B ONLY	Above Average	6
45 to ≤ 55	C	Average	5
40 to ≤ 45	P	Pass	4
< 40	F	Fail	0
Absent	Ab	Absent	0

Minimum grade for passing in a course or programme: The minimum for a pass in a course is 'P' grade. The minimum credit point requirement (CGPA) for the programme is four.

Revaluation

The answer scripts of examinations under CSS shall have provisions for revaluation. Evaluation or Scrutiny of answer scripts for the first and third semesters are provided. There is no provision for revaluation or scrutiny of answer scripts for the End Semester Examinations of second and fourth Semesters as double valuation is performed on the scripts. The application for scrutiny and revaluation of answer scripts shall be submitted to the Head of the concerned School/ Department/ Centre within 15 days from the date of publication of the results.

Reappearance and improvement in Examinations

A student who failed for a course in a semester can register for reappearance in the forthcoming examination, subject to the conditions set forth in these regulations. Improvement of marks/grades in the forthcoming examination can also be done, subject to the conditions in these regulations.

Registration for Improvement

A candidate has to apply for registration for improvement by paying the requisite fee. Candidates are not permitted to register for improvement of grades for Individual courses. Candidates in the first and second semesters, who have secured SGPA letter grade 'P' or above in the End Semester Examination can improve their grade by reappearing for all the semester courses along with the next immediate batch. In such cases a candidate will be awarded a new grade only if there is an improvement in grade in the new examination; otherwise, the candidate is eligible to retain the grade already awarded. Candidates in the third semester, who have secured the SGPA letter grade 'P' or above in the End Semester Examination, can improve their grade by reappearing for all the semester courses, along with

the third semester supplementary examination being conducted for failed candidates immediately after the completion of End Semester Examination of fourth semester. This provision is applicable only for the third semester. Improvement of the fourth semester can be done along with the immediate lower batch. If the improvement is meant to obtain minimum CGPA requirement, a candidate has the option to decide which semester (third or fourth) is to be improved; however, the grade given to the candidate shall be that obtained for the entire semester improvement examination. The first and second semester SGPA cannot be improved after the completion of the fourth semester. Only third and fourth semester SGPA can be improved after the completion of a programme. The marks/grades awarded for continuous assessment and that for the Project/dissertation cannot be improved. SGPA secured in the fourth semester can be improved only to fulfil the minimum CGPA requirement.

Reappearance

Candidates in the first and second semesters who have secured a grade of 'F' or 'Ab' in any of the courses can avail themselves two immediate consecutive chances to reappear for 23 examinations, course-wise, provided the candidate has applied for the same and paid the required fee. Candidate in the third semester who has secured a grade of 'F' or 'Ab' in any of the courses can reappear for exams course-wise in the third semester supplementary examination, which will be conducted immediately after the completion of the End Semester Examination of the fourth semester, provided the candidate has applied for the same and paid the required fee (fee for supplementary examination of any course shall be full semester examination fee irrespective of the number of courses involved). Candidates who secured the grade of only 'F' or 'Ab' in a course in the fourth semester examination can re-appear course-wise, along with the immediate lower batch. Candidates who secured the grade of only 'F' or 'Ab' in a course in the third/fourth semester examinations will be given two additional chances for course-wise reappearance even after the completion of the programme; but it has to be done within two years after the completion. In such cases, a candidate has to apply for the same as a supplementary exam and pay the required fee (The fee for supplementary examination of any course shall be full semester examination fee irrespective of the number of courses involved).

(As per the M G university CSS regulations amended from time to time)

Scheme and Syllabi

Programme 2

M. Sc. Chemistry (Organic Chemistry)

MAHATMA GANDHI UNIVERSITY

SCHOOL OF CHEMICAL SCIENCES

PROGRAMME : M. Sc. Chemistry (Organic Chemistry)

DURATION : 2 years (2021 Admission onwards)

Total credits required : 86 (for 4 semesters) [Core: 62; Elective: 20; Open: 4]

* The student has to choose **three elective courses** for semester I, **three elective courses** for semester II and **two elective courses** for semester III and **two elective courses** for semester IV

** The student has to choose **one open course** of 4 credits for semester III from any other School under the Faculty of Science.

*** In the evaluation process internal –Continuous Assessment (CA) - accounts for 40% and the End- Semester Examination will account for the remaining 60%.

Program Specific Outcomes (PSOs): At the completion of the M.Sc. Chemistry (Organic Chemistry) program, the students should be able to:

PSO	Expected outcome
1	Provide a strong foundation in Chemistry that emphasizes scientific reasoning and analytical problem-solving.
2	Provide students with the skills required to succeed in M.Sc., also enrich the students with basic skills to perform in the Chemical industry
3	Promote research interest in students and enable them to plan and execution research in frontier areas of chemical sciences
4	Expose the students to a level of experimental techniques using modern instrumentation.
5	Develop teamwork, communication, time management and leadership skills across multicultural contexts
6	Acquire firm knowledge of fundamental theories, and concepts of all branches of Chemistry and able to apply them to advanced studies and be able to develop analytical thinking and apply the same for the understanding of underlining principles, proposing mechanisms, problem solving, identification of chemical species and arriving to logical conclusions.
7	Gain knowledge in classical laboratory techniques and be able to use modern instrumentation, so that they can perform new experiments, and obtain experimental data and its interpretation through theoretical principles.

SEMESTER I (23 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
Core Courses						17
CSM21C02	Quantum Mechanics and Atomic Structure	2	2	-	3	
CSM21C03	Chemical Thermodynamics	2	2	-	3	
CSM21C04	Molecular Spectroscopy	2	2	-	3	
CSM21C05	Organic Reaction Mechanisms	2	2	-	3	
CSM21C06	Inorganic Chemistry Lab-I	-	-	6	2	
CSM21C07	Stereochemistry and Conformations of Organic Compounds	2	2	-	3	
***Elective Courses (Choose any three)**						6
CSM21E41	Equilibrium Statistical Mechanics	2	-	-	2	
CSM21E42	Introduction to Polymer Chemistry	2	-	-	2	
CSM21E43	Supramolecular Chemistry	2	-	-	2	
CSM21E44	Theory of Polymer Solutions	2	-	-	2	
CSM21E46	Main Group Elements Chemistry	2	-	-	2	

SEMESTER II (22 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
Core Courses						16
CSM21C12	Structural and Solid-State Chemistry	2	2	-	3	
CSM21C13	Photochemistry and Pericyclic Reactions	2	2	-	3	
CSM21C14	Spectroscopic methods in Chemistry	2	2	-	3	
CSM21C15	Physical Chemistry Lab-I	-	-	6	2	
CSM21C16	Organic Chemistry Lab-I	-	-	6	2	
CSM21C17	Reactions and Reagents in Organic Chemistry	2	2	-	3	
***Elective Courses (Choose any three)**						6
CSM21E51	Bioinorganic Chemistry	2	-	-	2	
CSM21E52	Chemical Bonding and Group Theory	2	-	-	2	
CSM21E55	Biochemistry	2	-	-	2	
CSM21E56	Natural and Synthetic Polymers	2	-	-	2	
CSM21E57	Medicinal Chemistry	2	-	-	2	
CSM21E58	Chemistry of Heterocyclic Compounds	2	-	-	2	
CSM21E59	Chemistry of Coordination Compounds	2	-	-	2	

SEMESTER III (22 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
Core Courses						14
CSM21C21	Organometallic Chemistry	2	2	-	3	
CSM21C22	Analytical and Nuclear Chemistry	2	2	-	3	
CSM21C23	Chemical Kinetics	2	2	-	3	
CSM21C26	Advanced Organic Synthesis	2	2	-	3	
CSM21C27	Organic Chemistry Lab– II	-	-	6	2	
***Elective Courses (Choose any two)**						4
CSM21E71	Fundamentals of Electrochemistry	2	-	-	2	
CSM21E72	Computational Methods in Chemistry	2	-	-	2	
CSM21E74	Surface Chemistry and Catalysis	2	-	-	2	
CSM21E76	Chemistry of Natural Products	2	-	-	2	
CSM21E77	Nanomaterials	2	-	-	2	
CSM21E82	Industrial Chemistry	2	-	-	2	
****Open Courses (Choose any one)**						4
CSM21O86	Environmental Chemistry	4	-	-	4	
CSM21O87	Science and Society	4	-	-	4	

SEMESTER IV (19 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
Core Courses						15
CSM21C35	Research Project and Seminar	-	-	-	9	
CSM21C36	Comprehensive Viva-voce	-	-	-	3	
CSM21C38	Advances in Organic Chemistry	2	2	-	3	
***Elective Courses (Choose any one)**						4
CSM21E91	Review Report	-	2	-	2	
CSM21E92	Industry Visit Report	-	-	-	2	
CSM21E94	Instrumental Methods in Organic Chemistry	2	-	-	2	

	MAHATMA GANDHI UNIVERSITY
	CSM21C02 Quantum Mechanics and Atomic Structure

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Quantum Mechanics and Atomic Structure**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C02**					
Course Summary & Justification	Learning this course helps to develop concepts in quantum mechanics such that the behaviour of the physical universe can be understood from a fundamental point of view. It provides a strong foundation for further studies on quantum mechanics, molecular spectroscopy, and chemical bonding. The Content will include Review of the Schrodinger equation, The concept of the wave function, and Orbital. Degeneracy etc. It also gives an insight into a particle in a box, the harmonic oscillator, the rigid rotor and the hydrogen atom.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge in Quantum Mechanics and mathematics, Basics of classical mechanics, dual nature of matter, basic knowledge of differential equations.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Basic knowledge of Quantum Mechanics	U	1
2	Understand the inadequacy of classical mechanics and the origin of quantum mechanics	U	1
3	Identify the operator formulation of quantum mechanics	R	1
4	Solve and derive the Schrodinger equation	E	1
5	Apply the principles of quantum mechanics to particle in a box, harmonic oscillator and rigid rotor	A	1

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT	**Hours**	**CO No**

Unit 1: From classical to quantum mechanics Content for Classroom Transaction (Sub-units) 1.1. Plank's quantum postulates 1.2. Blackbody radiation 1.3. Photo-electric effect 1.4. Wave-particle duality 1.5. Double-slit experiment 1.6. Heisenberg's Matrix mechanics (summary) 1.7. Deduction of Schrodinger Wave mechanics from classical mechanics	4	1, 2
Unit 2: Formulation of Quantum mechanics Content for Classroom Transaction (Sub-units) 2.1. The postulates and general principles of quantum mechanics 2.2. Fundamental theorems of quantum mechanics 2.3. Time-dependent and time-independent Schrodinger equations 2.4. Stationary states 2.5. Formulation of quantum mechanical problem. 2.6. Concept and Rules of proper behavior of operators and their physical significance.	10	3, 4
Unit 3: Quantum mechanical description of simple systems Content for Classroom Transaction (Sub-units) 3.1. The particle in a one-dimensional box-complete treatment. 3.2. The particle in a three-dimensional box, Separation of variables, Degeneracy, Symmetry breaking 3.3. Treatment of more than one particle (non-interacting) in a box and its applications 3.4. Tunnelling 3.5. Harmonic Oscillators Classical concepts. 3.6. Derivation of Schrödinger equation. 3.7. Harmonic oscillator (complete treatment): Wave functions and energies & molecular vibrations, 3.8. Three-dimensional harmonic oscillator	12	5
Unit 4: Angular momentum Content for Classroom Transaction (Sub-units) 4.1. Rigid rotator (compete treatment) 4.2. The wave equation in spherical polar coordinates. 4.3. Planar rigid rotator (or Particle on a ring), Wave functions in the real form, Polar diagrams. 4.4. Nonplanar rigid rotators (or particle on a sphere), Separation of variables. 4.5. Legendre and Associated Legendre equations, polynomials & Spherical harmonics 4.6. Polar diagrams of spherical harmonics. 4.7. Angular momentum operators and their commutation relations 4.8. Spherical harmonics as Eigen functions and eigen values of angular momentum operators 4.9. Quantization of angular momentum, Space quantization.	10	5

Unit 5: Quantum mechanical treatment of hydrogen-like system Content for Classroom Transaction (Sub-units) 5.1. Potential energy of hydrogen-like systems. 5.2. The wave equation in spherical polar coordinates, Separation of variables. 5.3. Wave functions and energies of hydrogen-like atoms, Orbitals. 5.4. Radial functions, Radial distribution of functions and their plots 5.5. Angular functions (Spherical harmonics) and their plots, Orbital diagrams. 5.6. Explanation of Hydrogen spectrum, Fine structure, 5.7. The postulate of spin by Unlebeck and Goldsmith, 5.8. Dirac's Relativistic Schrodinger equation for hydrogen atom and discovery of spin, 5.9. Hydrogen wave functions including spin or spin orbitals, 5.10. Construction of Spin orbitals from Orbitals and Spin functions.	12	5
Unit 6: Many-electron Systems Content for Classroom Transaction (Sub-units) 6.1. Many-body problem. Approximation methods 6.2. Variation methods, Variation theorem with proof 6.3. Perturbation method. Time-independent perturbation method (non-degenerate case only). Hartree-Fock Self-Consistent Field (HF-SCF) method. 6.4. Slater's treatment of complex atoms, Slater Orbitals, 6.5. Electron spin and atomic structure- Construction of wave functions including spin for many-electron atoms 6.6. Symmetric and antisymmetric wave functions, Pauli's antisymmetric principle, Slater determinants, 6.7. Pauli's exclusion principle. 6.8. Vector model of atoms and spectroscopic terms 6.9. Coupling of angular momenta, LS and jj-couplings, LS coupling and Spectroscopic term symbols for atoms. 6.10. Brief mention of selection rule in atomic spectroscopy.	12	5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

REFERENCES

1. A. McQuarrie, Quantum Chemistry, 2nd Edn. University Science Books, 2007.

2. J. P. Lowe, Quantum Chemistry, 2nd Edn. Academic Press, 1993.
3. N. Levine, Quantum Chemistry, 5th Edn. Prentice Hall, 1999.

	MAHATMA GANDHI UNIVERSITY
	CSM21C03 Chemical Thermodynamics

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Chemical Thermodynamics**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C03**					
Course Summary & Justification	An introduction to classical thermodynamics and surface Chemistry. Topics to be covered include Zeroth law of thermodynamics, first law of thermodynamics, enthalpy, entropy, second and third law of thermodynamics, Helmholtz and Gibbs energies, chemical potential, phase diagrams and surface chemistry. Chemical thermodynamics helps to establish and develop the principles that are used to explain and interpret many of the physical and chemical observations. Also, it explains many of the proposed hypotheses in terms of fundamental concepts. It imparts correctness and depth of sophistication to conceptual arguments in physical chemistry. Surface chemistry helps to understand surface phenomena and physical methods for studying surfaces.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Bachelors degree in chemistry, with physics and mathematics as subsidiaries.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Be able to describe the fundamental scientific principles of thermodynamics and apply these principles in assignments, discussions on/offline, and new problems.	U	1, 5
2	Obtain problem-solving skills in physical chemistry by solving assignments, quizzes and on/off-line discussions and lecture material.	A, E, S, I	3, 5
3	Be able to apply the knowledge to predict and rationalize the physical and chemical properties of systems and the direction in which chemical and physical processes proceed.	Ap	1, 2

4	To provide students with the skills required to succeed in the Master program.	A	1, 7
5	Recognize assumptions and limitations in the scientific models and their possible impact on the results by training on case studies, lectures, assignments, quizzes	U	1,2
6	(i) Be able to work productively and collaboratively as a team member by solving problems with other students. (ii) Evaluate the potential impact of thermodynamics may have on daily life, health and the environment.	U	4, 5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO NO
Unit 1: First Law of Thermodynamics 1.1. Variables of thermodynamics, theoretical methods, Practical techniques. 1.2. The first law of thermodynamics, thermodynamic functions, Joule Thomson effect. Coefficient of thermal expansion, Application of First law to a cyclic process.	8	1, 2, 6
Unit 2: Second Law of Thermodynamics - Entropy 2.1. The Clausius inequality. 2.2. Entropy changes accompany expansion, phase transition and heating. 2.3. Free energy functions. 2.4. Relation between thermodynamic functions. Maxwell relations. Variation of entropy with temperature and pressure 2.5. Third law of thermodynamics: Need for third law Calculation of absolute entropy, unattainability of absolute zero.	10	1, 3, 6
Unit 3: Partial Molar Quantities and Chemical Potential 3.1. Gibbs-Duhem equation, determination of partial molar volume and enthalpy. 3.2. Fugacity, relation between fugacity and pressure, determination of fugacity of a real gas, variation of fugacity with temperature and pressure. 3.3. Activity, the dependence of activity on temperature and pressure. 3.4. Thermodynamics of mixing, Gibbs-Duhem-Margules equation 3.5. Konowaloff's rule, Henry's law 3.6. Excess thermodynamic functions – free energy, enthalpy, entropy and volume, determination of excess enthalpy and volume.	12	3, 5, 6
Unit 4: Chemical Equilibria 4.1. Chemical affinity and thermodynamic functions, effect of temperature and pressure on chemical equilibrium 4.2. vant Hoff reaction isochore and isotherm 4.3. Nernst heat theorem	10	3, 5, 6
Unit 5: Phase Rule 5.1. Application to one, two and three component systems. 5.2. Liquid-vapour equilibria of binary systems.	10	3, 5, 6
Unit 6: Applications of free energy function to physical and chemical changes 6.1. Equilibrium in chemical reactions.	10	5, 6

6.2. Effect of temperature and pressure on the chemical equilibrium- Van't Hoff reaction isochore and isotherm		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brainstorming lecture, Explicit Teaching, E-learning, **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test - On MCQ based and extended answer type • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar **B. End semester examination**

REFERENCES

1. P. Atkins, J. de. Paula, Physical Chemistry, 8th Edn. Oxford University Press, 2006.
2. P. Bolgar, H. Lloyd, A. North, V. Oleinikovas, S. Smith, J. Keeler, P. Atkins' Physical Chemistry, 11th Edn. Oxford University Press, 2017

SUGGESTED READINGS

1. A. McQuarrie, J. D. Simon, Molecular Thermodynamics, University Science Books, 2004.
2. R. S. Berry, S. A. Rice, J. Ross, Physical Chemistry, 2nd Edn. Oxford University Press, 2007.
3. R. A. Alberty, R J Silbey, Physical Chemistry, 4th Edn. J. Wiley & Sons, 1994
4. F. Daniels, R. A. Alberty, Physical Chemistry, 8th Edn. Wiley, New York, 1994
5. P. W. Atkins, Physical Chemistry, 8th Edn. Wiley, New York, 2006
6. W. Adamson, The Physical Chemistry of Surfaces, 2nd Edn. Wiley. New York, 1998
7. G. A. Somorjai, Chemistry of Surfaces, 3rd Edn. Wiley, New York, 2005
8. A. E. Alexander, P. Johnson, Colloid Science, Oxford University Press, Oxford, New York, 1996.

	MAHATMA GANDHI UNIVERSITY
	CSM21C04 Molecular Spectroscopy

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Molecular Spectroscopy**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C04**					
Course Summary & Justification	This course is designed at providing students with theoretical concepts of various spectroscopy, i.e., Atomic, Molecular, Vibrational, Raman, NMR, EPR, Mossbauer and electronic to analyse the molecular and electronic structure of atoms and molecules. Interaction of light with molecules, spectral transitions, and theoretical explanation of spectral data will be discussed. Students will be able to use quantum mechanics and group theory principles to understand molecular spectra; Also, they will be able to identify the relationship between molecular spectra and molecular properties which will help the students to analyse the structure of atoms and molecules using spectroscopic methods. Spectroscopy is a multidisciplinary subject and the spectroscopic tools are significant to characterize the structure and properties of new compounds designed for various applications. Thus, spectroscopy is inevitable in areas of chemistry, physics, biochemistry, medical fields, chemical industry, etc. Learning this course will provide a strong foundation in the key concepts of spectroscopy and will help the students to identify the use of appropriate spectroscopic techniques for the characterization of various molecules. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge about spectroscopy at the Bachelor's level					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	*After Completion of this course, the student should be able to;* Understand the interaction of light with matter and the key concepts of spectroscopy to probe the structure of molecules.	U	1
2	Apply quantum mechanics and group theory principles to understand molecular spectra	A	3
3	Identify the relationship between molecular spectra and molecular properties	Ap	2, 4, 5
4	Analyses and explain the structure of atoms and molecules using various spectral data.	A	2, 4, 5
5	Evaluate the utility of various spectroscopy as a qualitative and quantitative method.	U	6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No.
Unit 1: Introduction to Spectroscopy Content for Classroom Transaction (Sub-units) 1.1. Origin of different spectra, intensity of absorption 1.2. Signal-to-noise ratio, natural line width 1.3. Influencing factors spectral intensity-transition probability, Maxwell-Boltzmann distribution 1.4. Contributing factors-Doppler broadening, Lamb dip spectrum 1.5. Beers-Lamberts law 1.6. Born Oppenheimer approximation 1.7. Energy dissipation from excited states, relaxation time.	5	1
Unit 2-Microwave Spectroscopy		
Content for Classroom Transaction (Sub-units) 2.1. Principal moments of inertia and classification (linear, symmetric tops, spherical tops and asymmetric tops), rigid and non-rigid rotators 2.2. Selection rules, 2.3. Intensity of rotational lines, relative population of energy levels, derivation of J max, effect of isotopic substitution, 2.4. Calculation of intermolecular distance, 2.5. Stark effect and its application, nuclear and electron spin interaction	7	2, 3, 4, 5
Unit 3: Infrared Spectroscopy		
Content for Classroom Transaction (Sub-units) 3.1. Vibrational energy of diatomic molecules, Harmonic Oscillator, selection rules 3.2. Anharmonicity 3.3. Morse potential energy diagram, fundamentals, overtones and hot bands, 3.4. Determination of force constants, diatomic vibrating rotator, breakdown of the Born-Oppenheimer approximation, effect of nuclear spin	7	2, 3, 4, 5

3.5. Vibrational spectra of polyatomic molecule 3.6. Normal modes of vibrations, combination and difference bands 3.7. Fermi resonance, fingerprint region and group vibrations, overtones, hot bands 3.8. Effect of H-bonding on group frequency 3.9. FTIR		
Unit 4: Raman Spectroscopy		
Content for Classroom Transaction (Sub-units) 4.1. Introduction to Raman spectroscopy 4.2. Classical and quantum theories of Raman effect 4.3. Rotational and vibrational Raman spectrum 4.4. Complementarities of Raman and IR spectra, mutual exclusion principle 4.5. Polarized and depolarized Raman lines 4.6. Resonance Raman scattering and resonance fluorescence	7	2, 3, 4, 5
Unit 5: Electronic Spectroscopy		
Content for Classroom Transaction (Sub-units) 5.1. Term symbols and electronic spectra of diatomic molecules, 5.2. Selection rules, 5.3. Franck-Condon principle, predissociation, calculation of heat of dissociation-Birge and Sponer Method, fortrat diagram 5.4. Electronic spectra of polyatomic molecules, radiative and non-radiative decay, Jablonski diagram 5.5. Different types of lasers-solid state, continuous wave, gas and chemical lasers, frequency doubling	9	2, 3, 4, 5
Unit 6: NMR Spectroscopy Content for Classroom Transaction (Sub-units) 6.1. Nuclear spin interaction with the magnetic field, 6.2. Nuclear energy levels and its population, 6.3. Larmor precession, 6.4. Relaxation methods, 6.5. Factors affecting nuclear relaxation 6.6. Chemical shift, exchange phenomenon, factors influencing coupling, Karplus relationship. variation of coupling constant with dihedral angle, 6.7. FT-NMR, second-order effects on spectra, spin systems (AB, AB2), 6.8. Simplification of second-order spectra-shift reagents, 6.9. The contact and pseudo-contact shifts 6.10. High field NMR, double irradiation, selective decoupling, 6.11. Double resonance, NOE effect, two-dimensional NMR-COSY and HETCOR 6.12. Resonance of other nuclei 6.13. ^{13}C NMR-chemical shift and structure correlation, 6.14. ^{13}C coupling constants 6.15. Solid state NMR 6.16. Magic angle spinning. 6.17. Elementary study of NQR spectroscopy.	12	2, 3, 4, 5

Unit 7: EPR Spectroscopy 7.1. Electron spin interaction with magnetic field, 7.2. Hyperfine coupling, spin-orbit coupling 7.3. g factor, significance of g factor, determination of $g_{\parallel}$ and $g^{\perp}$, 7.4. Fine and hyperfine structures, Kramers' degeneracy, 7.5. McConnell equation.	8	2, 3, 4, 5
Unit 8: Mossbauer Spectroscopy		
8.1. Basic principles, Doppler effect, 8.2. Chemical shift, application to metal complexes	5	2, 3, 4, 5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction: Explicit Teaching, E-learning, interactive Instruction: Seminar, Group Assignments, Authentic learning, Library work and Group discussion, Presentation by individual students
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment** • Seminar Presentation **B. Semester End examination**

REFERENCES

1. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn. Tata McGraw Hill, 1994.

SUGGESTED READINGS

1. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India, 2001.
2. H. Kaur, Spectroscopy, 6th Edn. Pragati Prakashan, 2011.
3. R. S. Drago, Physical Methods in Chemistry, Saunders College, 1992.
4. K. J. Laidler, J. H. Meiser, Physical Chemistry, 2nd Edn. CBS, 1999.
5. N. Sathyanarayana, Electronic Absorption Spectroscopy and Related Techniques, Universities Press, 2001.

	MAHATMA GANDHI UNIVERSITY
	CSM21C05 Organic Reaction Mechanisms

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Organic Reaction Mechanisms**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C05**					
Course Summary & Justification	Learning reaction mechanisms is very important for a chemistry student to have a basic knowledge about the course and the outcome of different reactions. A thorough understanding of organic reaction mechanisms is extremely useful in predicting the products and improving the reaction efficiency. A student needs to know basic concepts of organic chemistry to be able to write reasonable reaction mechanisms. A mechanism cannot be considered valid unless there is experimental evidence to support it. The student needs to know basic experiments that can be used to validate reaction mechanisms.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge in organic chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No
1	Propose the mechanism of a given organic reaction	U	1
2	Predict the product formed in a reaction under specified conditions	A	1, 2
3	Identify the change in the mechanism and the product formed with the change in reaction conditions	Ap	1, 2, 3
4	To predict the mechanisms of different molecular rearrangements	An	2, 3
5	Describe reaction mechanisms in terms of energetics, reaction kinetics, and thermodynamics.	U	3
6	Correlate the reactivity of a compound with its structure.	C	3

7	Evaluate the yield of a particular product in a mixture under a set of conditions	E	5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Chemical bonding and molecular structure Content for Classroom Transaction (Sub-units) 1.1. Valence Bond Theory 1.2. Molecular Orbital Theory 1.3. Electronic effects 1.4. Acids and bases 1.5. Hammett and Taft equations 1.6. linear free energy relationships 1.7. Solvent polarity scales- Gurundwald-Winstein equation	10	1, 2, 3, 6, 7
Unit 2: Kinetic and thermodynamic aspects Content for Classroom Transaction (Sub-units) 2.1. Kinetic versus thermodynamic control 2.2. Hammond's postulate and Curtin-Hammett principle 2.3. Isotope effects 2.4. Catalysis by acids and bases 2.5. Lewis acid catalysis 2.6. Methods to find reaction mechanisms	8	2, 3, 6, 7
Unit 3: Nucleophilic substitution reactions Content for Classroom Transaction (Sub-units) 3.1. Nucleophiles and electrophiles 3.2. Comparison between nucleophilicity and basicity 3.3. Detailed study of SN1, SN2, SNi, SN11, SN21, and borderline mechanisms. 3.4. Nucleophilicity, Leaving group effect and solvent effects 3.5. Neighboring group participation 3.6. Phase transfer catalysis (PTC) and application of crown ethers. 3.7. Rearrangement of carbocations, the norbornyl cation and other nonclassical carbocations, superacids	12	1-7
Unit 4: Addition and elimination reactions: Content for Classroom Transaction (Sub-units) 4.1. Mechanism of addition reactions 4.2. addition of hydrogen halides to alkenes, 4.3. addition of halogens 4.4. addition of metallic species-hydroboration, oxy-mercuration 4.5. elimination reactions (E1, E2 and E1cB mechanisms) 4.6. dehydrohalogenation, 4.7. dehydration of alcohols, 4.8. substitution versus elimination	10	1-7

Unit 5: Aromatic substitution reactions Content for Classroom Transaction (Sub-units) 5.1. Aromatic electrophilic substitution reactions-mechanism 5.2. Partial rate factors 5.3. Nitration, halogenation, sulphonation and Friedel-Crafts reactions 5.4. Activating/deactivating, *ortho-para* and *meta* orienting effects in substituted benzenes. 5.5. Aromatic nucleophilic substitution reactions-benzyne mechanism 5.6. Substitution on polynuclear aromatic systems.	10	1, 2, 3, 5
Unit 6: Selected rearrangements in organic chemistry Content for Classroom Transaction (Sub-units) (Ten rearrangement reactions with mechanisms)	4	1, 2, 4, 6
Unit 7: Mechanisms of nucleophilic substitution of carbonyl compounds Content for Classroom Transaction (Sub-units) 7.1. Reactivity of carbonyl groups 7.2. Addition and substitution reactions 7.3. Hydrolytic reactions Ester and amide hydrolysis reactions –different mechanisms. 7.4. Esterification and trans-esterification reaction	6	3-7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments Seminar, Authentic learning, Library work, independent studies Presentation by individual student
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

REFERENCES

1. F. A. Carey, R. J. Sundberg, Advanced organic chemistry part-A. 5th Edn. Springer, 2007
2. J. March, Advanced organic chemistry, 6th Edn. 2007
3. J. Clayden, N. Greeves, S Warren, P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001
4. P. Sykes, A Guide Book to Mechanism in Organic Chemistry Longman, New York, 1985
5. T. H. Lowing, K. S. Richard, Mechanism and theory in Organic Chemistry 3rd Edn. Harper Collins Publishers. New York, 1987
6. J. Hine, Physical Organic chemistry, McGraw-Hil, 2nd Edn. 1962.

	MAHATMA GANDHI UNIVERSITY
	CSM21C06 Inorganic Chemistry Lab-I

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Inorganic Chemistry Lab-I**					
Course Credit	**2**					
Type of Course	**CORE**					
Course Code	**CSM21C06**					
Course Summary & Justification	The laboratory practical course enables the students to understand and apply the lab skills and laboratory safety procedures needed to carry out standard chemistry experimental techniques. This course will facilitate the students to apply the basic concepts of inorganic chemistry to analyze the metal ions in a given sample. Through this course, the students will learn to (i) separate and identify cations in a given mixture (ii) estimate the metal ions using colorimetry (iii) perform complexometric titrations of metal ions with the double burette method (iv) separate and estimate binary mixture of metal ions using combined volumetric and colorimetric methods and (v) tabulate and analyze the results of all the experiments systematically. This course will improve the analytical skill and critical thinking including observation, hypothesis development, measurement and data collection, experimentation, evaluation of evidence, and employment of mathematical analysis.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	0	0	120	30	150
Pre-requisite	A chemistry laboratory is a place of discovery and learning but at the same time, it can be a place of danger if proper common-sense precautions are not taken care of. So the students are expected to learn and follow the general safety guidelines to ensure a safe laboratory environment. Also, basic knowledge of inorganic salt analysis, colorimetric estimations and complexometric titrations is preferred.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Perform basic chemical lab procedures by following appropriate lab safety measures & infer the experimental results with mathematical and analytical reasoning.	U	1
2	Separation and identification of the mixture of cations in a given sample	An	2
3	Estimation of the amount of metal ion present in the whole of the given solution colorimetrically.	E	2
4	Estimation of the amount of the metal ions in the whole of the given solution using complexometric titrations.	E	2
5	Estimation of binary mixtures of metal ions in the given solution using combined volumetric and colorimetric methods.	E	2
6	Develop the skills to carry out basic quantitative and qualitative analytical techniques.	S	3
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Separation and identification of a mixture of two cations Content for Classroom Transaction (Sub-units) Familiar cations: Ag^{+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Bi^{2+}, Cd^{2+}, As^{3+}, Sn^{2+}, Sb^{3+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Li^{+}, Na^{+}, K^{+} and NH_4^{+} Rare earth cations: Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li. Minimum five mixtures to be analyzed and recorded.	40	1, 2, 6
Unit 2: Colorimetric Estimations Content for Classroom Transaction (Sub-units) 2.1. Estimation of Ferric ion by thiocyanate method 2.2. Estimation of Copper by using diethyldithiocarbamate 2.3. Estimation of Chromium by using diphenyl carbazide 2.4. Estimation of Manganese by using potassium periodate Any two to be recorded.	20	1, 3, 6
Unit 3: Complexometric titrations Content for Classroom Transaction (Sub-units) 3.1. Estimation of Zinc 3.2. Estimation of Nickel (direct titration) 3.3. Estimation of Nickel (back titration)	20	1, 4, 6

Unit 4: Estimation of binary mixtures of metallic ions Content for Classroom Transaction (Sub-units) 4.1. Estimation of binary mixtures (Cu-Ni, Cu-Zn, Fe-Cr, Fe-Cu, Fe-Ni, Pb-Ca, Fe-Ca) of metal ions in solution by volumetric and colorimetric methods. Any three to be recorded	40	1, 5, 6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Authentic learning
Assessment Types	**Mode of Assessment** • Lab/Experiment skills • Lab record/Report • Viva-voce • Lab Discipline (participation, punctuality, accuracy)

REFERENCES

1. I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn. Longman, 1996.
2. I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman 1966.
3. M. Koltoff, E. B. Sandell, A Text Book of Quantitative Inorganic Analysis, 3rd Edn. McMillian, 1968.
4. V. V. Ramanujam, Inorganic Semimicro qualitative Analysis. The National Public Co. 1974.

	MAHATMA GANDHI UNIVERSITY
	CSM21C07 Stereochemistry and Conformations of Organic Compounds

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Stereochemistry and Conformations of Organic Compounds**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C07**					
Course Summary & Justification	Stereochemistry is a fundamental topic to understand the nature, property and mechanism of organic substances and processes and is inevitable to learn modern organic chemistry. Learning this course will provide a key concept of the reaction mechanism of organic reactions. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences. This course is designed at providing students with theoretical concepts of stereochemistry. Various concepts of stereochemistry such as molecular geometry, stereoisomerism, Cahn-Ingold-Prelog systems, different notations, racemization, resolution, asymmetric synthesis, configuration, conformation, anomeric effect, conformational analysis of butane, cyclohexane, decalin, stereochemistry & reactivity, stereochemistry of various reactions, all kinds of chirality, Atropisomerism, conformation & reactivity, stereoselective & stereospecific reactions, chiroptical properties such as ORD, CD and quadrant rule will be discussed. Students will be able to use stereochemical aspects to understand reaction mechanisms and to predict the stereochemistry of the product formed.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning, Collaborative learning, Independent learning	40	40	0	40	120
Pre-requisite	Basics of Organic chemistry including basic concepts of hybridisation and reaction pathways.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the basic concepts of symmetry elements and stereochemical aspects to assign notation of molecules and to predict the stereochemistry of products of reactions.	U	1
2	Assign R/S and E/Z notation for stereoisomers and to distinguish between enantiomers and diastereomers.	U	3
3	Calculate ee or de of stereoselective reaction to get a good understanding of asymmetric synthesis and absolute configuration.	A	2
4	Distinguish between various kinds of chirality, and predict the stereochemistry of cycloaddition reactions.	A	3
5	Able to predict the stereochemistry of products of asymmetric reactions.	A	6
6	Distinguish between stereoselective and stereospecific reactions and predict the regio- and stereochemistry of products of Aldol reactions.	S	6, 7
7	Able to predict the sign of ORD/CD of optically active compounds	A	4, 6

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT	Hours	CO No
Unit 1: Molecular geometry and Chemical bonding Rotation around bonds, Concepts of dihedral angle, Torsion strain, Molecular symmetry and chirality, Symmetry operations, Symmetry elements.	8	1
Unit 2: Stereoisomerism Conformation and chirality, Centre of chirality, Molecules with a single chiral centre, Cahn Ingold Prelog system, D & L, R & S, E & Z Configurations-Molecules with two or more chiral centres, Enantiomers and diastereomers.	10	2
Unit 3: Racemization and Resolution Asymmetric transformations and mutarotation, Optical purity and enantiomeric excess, Calculations of *ee* and *de,* Determination of configuration, Methods based on NMR spectroscopy, chemical transformations Asymmetric synthesis, Relative and absolute configurations, Relative configuration of diastereomers, Auwers Skita rule, NOE, Enzymatic resolution and desymmetrization, Anomeric effect.	10	2, 3
Unit 4: Conformational analysis Conformations of butane, propene, butanone, butadiene, Cyclohexanes, Decalines, Heteroatom hyperconjugation, anomeric effect and its theories, Stereochemistry and reactivity of steroids, Stereochemistry of addition and elimination reactions, Chirality in molecules devoid of chiral centres, Axial chirality, Planar chirality, Helicity, Stereochemistry of allennes, spiranes, biphenyls, helicenes, cyclophanes, annulenes, Atropisomerism, Topicity and pro stereoisomerism-topicity of ligands and faces, Stereochemistry in cycloaddition reactions.	6	4, 5

Unit 5: Conformation and Reactivity Quantitative correlation between conformation and reactivity, Curtin-Hammett principle, Conformation and reactivity applied to substitution, elimination and addition reactions.	4	4, 5
Unit 6: Stereoselective reactions Stereoselective and stereospecific reactions, Double stereo-differenciation, Enantioselective synthesis, Reactions of nucleophilic carbon, Generation of carbanions by deprotonation, Formation of enolates-regio and stereochemical considerations, Alkylation of enolates-dianion formation and alkylations reactions-Reactions of silyl enol ethers, Enamines and imine anions, Conjugate addition of carbon nucleophiles, Aldol reactions-Regio and stereochemistry, Intramolecular aldol condensation, Zimmerman-Traxler transition state, Organoboranes-formation and reactions-Formation of alcohols, ketones aldehydes and amines from organo boranes, Enantioselective hydroboration-hydroboration of alkynes, Asymmetric epoxidation-Sharpless epoxidation-Allylic oxidation.	12	5, 6
Unit 7: Molecular Symmetry and chiroptical properties ORD and CD, α-Haloketone rule, Octant rule applied to cyclohexanones, Conformation and reactivity, Classical and non-classical carbocations.	10	7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brainstorming lecture, Explicit Teaching, E-learning, **interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – One MCQ based and on extended answer type • Book review – every student to review a seminal work on Alternative Education and submit a report • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar • Field visit report – each student shall individually or in group visit an institution with demonstrated experience of alternative thoughts and prepare a report **B. Semester End examination**

REFERENCES

1. E. L. Eliel, S. H. Wilen, L. N. Mander, Stereochemistry of organic compounds, John Wiley, 2003
2. D. Nasipuri, Stereochemistry of organic compounds, New age international publishers, New Delhi 2004

SUGGESTED READINGS

1. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry Part A, 5th Edn. Springer, 2007
2. P. S. Kalsi, Stereochemistry Conformation and mechanism, Wiley Eastern, New Delhi, 1990

	MAHATMA GANDHI UNIVERSITY
	CSM21C12 Structural and Solid-State Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Structural and Solid-State Chemistry**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C12**					
Course Summary & Justification	The study of Structural and Solid-State Chemistry unravels the basic composition, structures, and properties of solids. Through this learning, it is possible to acquire relevant conceptual and procedural knowledge and to develop an understanding and appreciation of developments in various scientific and technological fields. Learning this course will provide a strong foundation in the key concepts of Solid-State Chemistry, which will help the students to develop a holistic view of elemental composition, structure and material design in science and technology. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge about chemistry at the Bachelor's level					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the fundamentals of crystallography, crystal systems, symmetry operations, point groups and space groups as an introduction to the concepts of underlying Solid-State Chemistry	U	1
2	Elucidate the crystal structure using X-ray diffraction and correlate the XRD information with crystal structure	A	1
3	Analyze and understand the structure of AX, AX_2, AO_2, AO_3, A_2O_3, ABO_3, AB_2O_4 type compounds, perovskites, spinels and inverse spinels	U, An	2, 3
4	Gain insight into the crystal structure, close packing and crystal defects in solids	U	1, 2, 3

5	Explain and rationalize the electronic, magnetic and electrical properties of solids	U	
6	Build a perspective on preparative methods in solid state chemistry and to understand the various thermal analysis methods to interpret thermograms and phase diagrams of various systems	U, An	6, 7
7	Gather a comprehensive idea about Low dimensional solids and get familiarized with their unique properties, size effect, and applications in multi-disciplinary fields	U	6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No.**
Unit 1: Crystallography Content for Classroom Transaction (Sub-units) 1.1. Classification of solids, lattices and unit cells, crystal systems, Bravais lattices 1.2. Crystal directions and planes Crystal symmetry-symmetry elements and operations, translational symmetry elements 1.3. Point groups, space groups, reciprocal lattices	10	1
Unit 2: X-ray diffraction 2.2. Bragg law, systematic absences, identification of compounds using powder diffraction 2.3. Rietveld refinement, basics of neutron diffraction, elements of electron microscopy	10	2
Unit 3: Close packing, Crystal structure and Crystal defects 3.2. Hcp and ccp, packing efficiency, radius ratio, coordination number, lattice energy, Born- Haber cycle 3.3. Structure of AX, AX_2. AO_2, AO_3, A_2O_3, ABO_3, AB_2O_4 type compounds, Perovskites, spinels and inverse spinals 3.4. Covalent solids, metals, alloys, solid solutions, interstitial compounds elements 3.5. Crystal defects and non-stoichiometry 3.6. Sharing of polyhedra, structure of silicates,	15	3, 4
Unit 4: Electronic properties of solids 4.2. Band theory, k-space, Brillouin zones, band structure, Fermi level, Fermi energy, density of states 4.3. Metals, insulators, semiconductors-types and structures, super conduction	6	5
Unit 5: Magnetic properties of solids 5.2. Diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism, anti-ferromagnetism, permanent magnets	6	5
Unit 6: Electrical properties 6.2. Ferroelectric, pyroelectric and piezoelectric	4	5

Unit 7: Preparative methods and Thermal analysis methods in solid state chemistry 7.1. Solid state reactions, solid state kinetics 7.2. Thermal analysis- Thermogravimetry (TG), Differential Thermal Analysis (DTA)and Differential Scanning Calorimetry (DSC)	6	6
Unit 8: Low-dimensional solids 8.1 Fullerenes, quantum dots, nanotubes and nanowire	3	7

Teaching and Learning Approach	**Classroom Procedure: Learning Approach Consists of** **Direct Instruction**: Brain storming Lecture, Explicit Teaching, E-learning Interactive Instruction, Seminar, Group Assignments, Flipping, Progressive tests, Blended learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test • Seminar Presentation on a related topic and review a journal paper in a particular area and present before peers **B. Semester End examination**

REFERENCES

SUGGESTED READINGS

1. R. West, Solid State Chemistry and its Applications, John-Wiley, 1984.
2. R. C. Buchanan, T. Park, Materials Crystal Chemistry, Marcel Dekker, 1997.
3. S. E. Dann, Reactions and Characterization of Solids, RSC, 2000.
4. L. A. Smart, E. A. Moore, Solid State Chemistry: An introduction, 3rd Edn. CRC Press, 2005.
5. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Inorganic Chemistry, 5th Edn. Oxford University Press, 2010.
6. N. R. Rao, J. Gopalakrishnan, New Directions in Solid State Chemistry, 2nd Edn. Cambridge University Press, 2004.

	MAHATMA GANDHI UNIVERSITY
	CSM21C13 Photochemistry and Pericyclic Reactions

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Photochemistry and Pericyclic Reactions**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C13**					
Course Summary and Justification	This course essentially encompasses two components. The first component is the advanced course materials on photochemical and photophysical processes and their applications. Here some modern instruments which work under the principle of photochemistry are discussed to get an understanding of the present and possible future applications of photochemistry. In addition, a concise discussion on reactive intermediates like singlet oxygen, carbenes and nitrenes is also included as an application of photochemistry. In the second part, pericyclic reactions are discussed with an emphasis on light-initiated and heat-initiated reactions and their different outcome. Most common and complex pericyclic reactions are discussed to get an understanding of the synthetic utility of this technique while designing complex molecules. Therefore, the second part gives an advanced know-how on synthetic organic chemistry with an added stress on photochemical pathways.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Hours
	Others include Research, fieldwork, Independent Learning, etc.	40	40	0	40	120
Credit Value & Course Status	3	Core Course				
Pre-requisite	Basics of Organic Chemistry, steroechemistry and reaction mechanisms					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Learn basic concepts of organic photochemistry and pericyclic reactions.	U	1, 2
2	Understand the reaction mechanism of organic photochemical reactions and pericyclic reactions.	U	1, 2

3	Predict the product of a reaction under photochemical or thermal conditions.	A	2, 3
4	Develop the skill to propose the possible mechanism of a given photochemical or pericyclic reaction.	S	2, 5, 6
5	Gain knowledge of the synthetic applications of organic photochemical reactions and pericyclic reactions.	Ap	3, 6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No.**
Unit 1: Photochemistry Content for Classroom Transaction (Sub-units) 1.1. Photochemical energy plank Condon Principle, Jablonski diagram singlet and triplet states, dissipation of photochemical energy, photosensitization, quenching, quantum efficiency and quantum yield 1.2. Photochemistry of alkenes-Photochemical reactions involving *cis-trans* isomerisation 1.3. Photochemistry of carbonyl compounds-Saturated and unsaturated ketones, Enones and Dienones, compounds n-π, π-π* transitions Norrish type I and Norrish type II cleavages, di- p -methane rearrangement 1.4. Photochemistry of aromatic compounds-Rearrangement of aromatic compounds, Barton's Reaction, Photofragmentation, Photoaddition, Photo substitution 1.5. Cycloaddition - Paterno- Buchi reaction, DeMayo reaction 1.6. Singlet oxygen generation 1.7. Photoinduced electron transfer and energy transfer reactions (PET), Marcus theory of photochemistry, Photochemical Generation 1.8. Structure and reactivity of carbenes and nitrenes 1.9. Photochemistry of nanomaterials and quantum dots 1.10. Single molecule photochemistry	30	1-5
Unit 2: Pericyclic Reactions Content for Classroom Transaction (Sub-units) 2.1. Classification of Pericyclic reactions- electrocyclic, cycloaddition and sigmatropic reactions 2.2. Stereochemical aspects of pericyclic reactions 2.3. Symmetry properties of molecular orbitals 2.4. Correlation diagrams 2.5. Woodward Hoffman rules 2.6. Analysis of Pericyclic reactions using Frontier Molecular Orbital (FMO) 2.7. Perturbational Molecular Orbital (PMO) theories 2.8. Exo–Endo selectivity in Diels-Alder reactions 2.9. Applications of pericyclic reactions	30	1-5

Teaching and Learning Approach	**Classroom Procedure: Learning Approach Consists of** Direct Instruction: Brain storming Lecture, Explicit Teaching, E-learning Interactive Instruction, Seminar, Group Assignments, Flipping, Progressive tests, Blended learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Assignment • Seminar • Performance during tutorial • Internal examination/Viva voce **B. Semester End examination**

References

1. R. B. Woodward, R. Hoffmann, The Conservation of Orbital Symmetry. Verlag Chemie, Weiheim and Academic Press, New York, 1970
2. G. B. Gill, M.R. Wills, Pericyclic Reactions, Chapman and Hall Chemistry Text Book Series, 1974
3. I. Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, London 1976.
4. S. M. Mukerji, Pericyclic Reactions - A Mechanistic Study, Mac Millan Company of India Ltd., New Delhi, 1979.
5. R. E. Lehr, A. P. Marchand, Orbital Symmetry, A Problem-solving Approach, Academic Press, 1972
6. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, Wiley Eastern Ltd., New Delhi, 1978
7. M. Persico, G. Granucci, Photochemistry: A Modern Theoretical Perspective (Theoretical Chemistry and Computational Modelling), SpringerLink, 2018.
8. Literature reviews

	MAHATMA GANDHI UNIVERSITY
	CSM21C14 Spectroscopic Methods in Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Spectroscopic Methods in Chemistry**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C14**					
Course Summary & Justification	Spectroscopic tools are significant to characterize the structure and properties of new compounds designed for various applications. Thus, spectroscopy is inevitable in areas of chemistry, physics, biochemistry, medical fields, chemical industry, etc. Learning this course will provide a strong foundation in the key concepts of spectroscopy and which will help the students to identify the use of appropriate spectroscopic techniques for the characterization of various molecules. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences. This course is designed at providing students with practical applications of various spectroscopic techniques, i.e., UV-vis., IR, NMR, and mass to analyse the molecular and electronic structure of atoms and molecules. Interaction of light with molecules and spectral transitions will be discussed. Students will be able to use these techniques for the characterization of various inorganic and organic compounds.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Bachelors degree in chemistry, with physics and mathematics as subsidiaries.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Acquires the ability to synthesize, and characterize compounds using laboratory and instrumentation techniques.	U	1, 3, 4, 6, 7
2	To expose the students to a level of handling experimental techniques using modern instrumentation.	A	1, 3

3	Analyze the data obtained from sophisticated instruments (like FTIR, NMR, GCMS, HPLC, GCMS UV-Vis, Fluorescence, and TGA) for structure determination and chemical analysis.	Ap	2, 4, 6
4	Analyses and explains the structure of atoms and molecules, presence of functional groups using various spectral data.	A	1, 4,
5	Work in the interdisciplinary and multidisciplinary areas of chemical sciences and its applications.	U	2, 3
6	(i) Be able to work productively and collaboratively as a team member by solving problems with other students. (ii) Evaluate the potential impact of various analytical techniques on society, health and the environment.	U	2, 3, 5
7	Apply appropriate techniques for the qualitative and quantitative analysis of chemicals in laboratories and industries.	C	3
8	Providing students with the skills required to succeed in master program also enrich them with basic skill to perform in R & D chemical industrial level	E	2
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Ultraviolet-visible and Chirooptical Spectroscopy 1.1. Energy levels and selection rules 1.2. Woodward-Fieser and Fieser-Kuhn rules. 1.3. Influence of substituent, ring size and strain on spectral characteristics. 1.4. Solvent effect, stereochemical effect, and non-conjugated interactions. 1.5. Chirooptical properties-ORD, CD, octant rule, axial haloketone rule, Cotton effect.	12	1 - 5
Unit 2: Infrared Spectroscopy 2.1. Fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions) 2.2. Influence of substituent, ring size, hydrogen bonding, vibrational coupling and field effect on frequency, determination of stereochemistry by IR technique. 2.3. IR spectra of C=C bonds (olefins and arenes) and C=O bonds.	10	1-5

Unit 3: Nuclear Magnetic Resonance Spectroscopy 3.1. Magnetic nuclei with special reference to ^{1}H and ^{13}C nuclei. 3.2. Chemical shift and shielding/deshielding, factors affecting chemical shift, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy. 3.3. ^{1}H and ^{13}C NMR scales. Spin-spin splitting: AX, AX_2, AX_3, A_2X_3, AB, ABC, AMX type coupling, 3.4. First order and non-first order spectra, Pascal's triangle, coupling constant, mechanism of coupling, Karplus curve, quadrupole broadening and decoupling, diastereomeric protons, virtual coupling, long-range coupling-epi, peri and bay effects. 3.5. NOE and cross-polarization. Simplification of non-first order spectra to first order spectra: shift reagents, spin decoupling and double resonance, off-resonance decoupling. 3.6. Chemical shifts and homonuclear/heteronuclear couplings. Basis of heteronuclear Decoupling 3.7. DEPT 3.8. 2D NMR and COSY, HOMOCOSY, HETEROCOSY and NOESY. Polarization transfer. 3.9. Selective Population Inversion. 3.10. 3-D NMR NOESY-HSQC and TOCSY-HSQC, HMQC	16	1-5
Unit 4: Mass Spectrometry 4.1. Ion production methods: Electron ionization (EI), chemical ionization (CI), Soft ionization methods: SIMS, FAB, MALDI, and DI; electron spray ionization (ESI). 4.2. Mass analysis: magnetic sector mass analyzer, double-focusing mass analyzer, Quadrapole mass analyzer, time-of-flight mass analyzer 4.3. Fragmentation patterns-nitrogen and ring rules. McLafferty rearrangement and its applications. HRMS, MS-MS, LC-MS, GC-MS.	12	1-5
Unit 5. Structural elucidation using spectroscopic techniques 5.1. Identification of structures of organic and inorganic compounds based on the data UV-Vis, IR, ^{1}H NMR, ^{13}C NMR, EPR, and Mass spectroscopy. 5.2. Interpretation of the given UV-vis., IR and NMR spectra.	10	3, 5, 6, 7, 8

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brainstorming lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – On MCQ based and extended answer type • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar **B. End semester examination**

REFERENCES

1. L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy, 3rd Edn. Brooks Cole, 2000.

2. R. S. Drago, Physical Methods in Chemistry, Saunders College, 1992.
3. W. Kemp, Organic Spectroscopy, 2nd Edn. Macmillan, 1987.

SUGGESTED READINGS

1. L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to Spectroscopy, 3rd Edn. Brooks Cole, 2000.
2. R. S. Drago, Physical Methods in Chemistry, Saunders College, 1992.
3. W. Kemp, Organic Spectroscopy, 2nd Edn. Macmillan, 1987.
4. B. Wilson Jr., J. C. Decius, P. C. Cross, Molecular Vibrations: The Theory of Infrared and Raman Vibrational Spectra, Dover Pub., 1980.
5. F. Taber, Organic Spectroscopic Structure Determination: A Problem Based Learning Approach, Oxford University Press, 2007.
6. R. M. Silverstein, G. C. Bassler, T. C. Morril, Spectroscopic Identification of Organic Compounds, 5th Edn. Wiley, 1991.
7. U. Rahman, M. I. Choudhary, Solving Problems with NMR Spectroscopy, Academic Press, 1996.
8. Online spectral databases including RIO-DB.

	MAHATMA GANDHI UNIVERSITY
	CSM21C15 Physical Chemistry Lab-1

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Physical Chemistry Lab-1**					
Course Credit	**2**					
Type of Course	**CORE**					
Course Code	**CSM21C15**					
Course Summary & Justification	To have hands-on experience with techniques for verifying physical and chemical properties					
Semester	**II**					
Total StudentLearningTime (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	0	0	120	30	150
Pre-requisite	Bachelors degree in chemistry, with physics and mathematics as subsidiaries.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To experiment on various instrumental techniques.	A	1, 4, 6
2	To measure various physical and chemical properties.	A	2
3	To describe the principles behind the experiment performed in the laboratory.	Ap	1
4	To interpret the experimental results obtained by various techniques.	An	4
5	To understand the principles behind the experiment performed in the laboratory.	U	5
6	The students will acquire knowledge of experimental techniques for controlling the chemical reactions.	C	1, 3, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: SURFACE CHEMISTRY 1.1. Study the adsorption of acetic acid by activated charcoal and verify the Langmuir and Freundlich adsorption isotherms.	20	1-6
Unit 2: CHEMICAL KINETICS 2.1. Study the kinetics of the acid-catalysed hydrolysis of methyl acetate and evaluate the value of the rate constant 2.2. Evaluate the activation energy for the acid catalysed hydrolysis of methyl acetate	16	1-6
Unit 3: PHASE EQUILIBRIA 3.1. Determine the transition temperature of the given salt hydrate 3.2. Determine the CST of phenol-water system 3.3. Role of an electrolyte on the CST of phenol-water system.	20	1-6
Unit 4: THERMODYNAMIC PROPERTIES OF SOLUTION 4.1. Determine the partition coefficient for the distribution of succinic acid between water and 1-butanol. 4.2. Determination of partition coefficient of benzoic acid between toluene and water.	12	1-6
Unit 5: CONDUCTOMETRY 5.1. Determination of cell constant 5.2. Verification of Onsager equation and determine the equivalent conductance at infinite dilution of strong electrolyte 5.3. Determine the concentration of the given strong acid by conductometric titration with a strong base	8	1-6
Unit 6: pH MEASUREMENTS 6.1. Determine the concentration of the given acid by pH measurements. 6.2. Determine the isoelectric point of the given amino acid by pH measurements	20	1-6
Unit 7: OPTICAL MEASUREMENTS IN CHEMISTRY 7.1. Determine the refractive index of the given liquid by Abbe refractometer, and hence the specific and molar refraction 7.2. Determine the molar refractivity of water, methanol, acetic acid, ethylacetate, 1, 4-carbon tetrachloride and calculate the refraction equivalents of C, H, O and Cl. 7.3. Determine the specific, molecular and intrinsic rotations of the given optically active substance. 7.4. Determine the concentration of the unknown solution of the optically active compound by polarimetric measurements. 7.5. To study the kinetics of inversion of cane sugar by optical rotation measurement	24	1-6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive Instruction: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion on the theoretical back ground of the experiments to be carried out. Presentation by individual student/ Group representative

Assessment Types	Mode of Assessment
	A. Continuous Internal Assessment (CIA) • Seminar Presentation – theory of each experiment to be discussed and present in the seminar • Viva-voce examination **B. End semester examination**

References

1. D. P. Shoemaker, C. W. Garland, J. I. Steinfeld Experiments in Physical Chemistry, 3rd Edn. McGraw-Hill, 1967.
2. B. Viswanathan, P. S. Raghavan, Practical Physical Chemistry, Viva Books Pvt. Ltd. New Delhi, 2005.
3. J. B. Yadav, Advanced Practical Physical Chemistry, 29th Edn. 2010, Krishna Prakashan Media Pvt. Ltd. Meerut.

MAHATMA GANDHI UNIVERSITY

CSM21C16 Organic Chemistry Lab-1

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Organic Chemistry Lab-1**					
Course Credit	**2**					
Type of Course	**CORE**					
Course Code	**CSM21C16**					
Course Summary & Justification	This course is designed to give the student awareness about the safety measures to be taken in the lab, familiarise the different glassware and equipment used, separation of the components presents in the given binary mixture organic compounds using appropriate separation methods and analysing the separated components using standard procedure. Students will be introduced to the structure, reactivity, and analysis of organic molecules. Preparation of different organic molecules from simple molecules is also included in the course.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	0	0	120	30	150
Pre-requisite	Basic knowledge in practical organic chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Learn how to handle organic chemicals, glassware and precautions to be taken for safety in a Chemistry lab	U	1, 2, 3
2	Able to separate the components from a mixture using suitable methods and analyse the components using various reagents and reactions.	U, A	1, 4, 5
3	Able to perform experiments individually and gain knowledge about principles and techniques involved in various experiments	An	2, 3
4	Evaluate the properties of synthesized compounds through spectroscopic and analytical data	U, An, E	2, 3, 7
5	Analyse the mechanisms of the reactions in the experiment performed.	C, S, Ap	2, 3, 6,7

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT	Hours	CO No
UNIT 1: ORGANIC ANALYSIS Content for Laboratory Transaction (Sub-units) 1.1 Organic analysis-separation of two-component mixtures 1.2 Identification of individual components. 1.3 Separation, Purification and analysis of the components 1.4 Preparation of their derivatives. 1.5 Determination of physical constants of the components and its derivatives 1.6 Preparation of simple organic molecules and identification using Physical methods	80	1, 2, 3, 5
UNIT 2: ORGANIC PREPARATIONS Content for Laboratory Transaction (Sub-units) 2.1 Preparation of simple organic molecules 2.2 Characterisation of the prepared compounds by determining m.p/b.p, chromatographic and spectroscopic techniques	40	1, 3, 4

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments Seminar, Authentic learning, Library work, independent studies Presentation by individual student
Assessment Types	**Mode of Assessment** • Lab/Experiment skills • Lab record/Report • Viva-voce • Lab Discipline (participation, punctuality, accuracy)

REFERENCES

1. I. Vogel, B. S. Furniss, Vogel's Text Book of Practical Organic Chemistry, 5th Edn. 1989.
2. B. Dey, M. V. Sitaraman, T. R. Govindachari, Laboratory Mole of Organic Chemistry, Allied Publishers, 1992.
2. M. P. Doyle, W. S. Mungall, Experimental Organic Chemistry, John Wiley & Sons, 1980.
3. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 4th Edn. Pearson Education, 2009.

	MAHATMA GANDHI UNIVERSITY
	CSM21C17 Reactions and Reagents in Organic Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Reactions and Reagents in Organic Chemistry**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C17**					
Course Summary & Justification	Understanding reactions and reagents are the core of organic chemistry study. This enables to understand the various reagents and reactions needed to carry out a reaction and is inevitable to understand modern organic chemistry. Learning this course will provide a key concept of the reaction mechanism. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences. This course is designed to provide students with a good understanding of organic reactions and their applications. This knowledge will be very beneficial in medicinal chemistry, especially drug discovery.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Basics of Organic chemistry including basic concepts of stereochemistry and reaction pathways.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Acquires the ability to design reactions.	U	1
2	Acquires the skill to propose the mechanism of reactions.	U	3
3	Students will be able to predict suitable reaction conditions to carry out organic reactions.	A	2, 3, 4
4	Acquires the knowledge to transform molecules using functional group interconversions.	A	4, 5
5	Work in the interdisciplinary and multidisciplinary areas of chemical sciences and its applications.	A	6, 7

6	Be able to work productively and collaboratively as a team member by solving problems with other students.	S	5, 6, 7
7	Provide students with the skills required to succeed in master program and enrich them with a basic skill to perform at R & D chemical industrial level.	A	4-7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Carbanion Chemistry Robinson annulation, Condensation involving imine and iminium ions, Mannich and Knoevenagel reactions, Acylation of trimethylsilyl carbanions, Peterson carbanions, Wittig reaction, Sulfur ylides, Darzens reaction, Acyl anion equivalents-lithio-1,3-dithianaes, Umpolung.	8	1, 2
Unit 2: Organometallic Chemistry Organo- lithium and magnesium reagents - Formation and reactions, Organozinc reagents- Reformatsky reaction, Organocopper intermediates, Organopalladium reagents, Vinylation of aryl and alkenyl halides, Use of Organo Li, Cu, Cd, Hg, B, P, Si reagents in organic synthesis	12	2, 3
Unit 3: Electrophilic Reactions Electrophilic reactions of C-C multiple bonds, Oxymercuration, Iodolactonization, selenolactonization, Cycloaddition induced by electrophilic sulfur reagents, α-halogenation, sulfenylation and selenylation of carbonyl compounds, Hydration of alkynes.	12	4, 5
Unit 4: Oxidation Reactions Oxidation Reactions- Oxidation of C-C and C=C to oxiranes, 1,2-diols and carbonyl compounds, Oxidative cleavage-Ozonolysis, Singlet oxygen, Oxidation of alcohols to ketones, Oxidative rearrangements to ketones, Considerations of the selectivity of common reagents for oxidation- B_2H_6/H_2O_2 peracids, SeO_2, Quinones, Tl^{3+}, CrO_3, $KMnO_4$, MnO_2, OsO_4, $AgOAc/I_2$, $Cu(OAc)_2$, $NaIO_4$, DMSO.	14	5, 6, 7
Unit 5: Reduction Reactions Reduction Reactions-Catalytic hydrogenation, Hydrogenation of C-C multiple bonds-Birch reduction, Diborane and alkyl boranes, Reduction of aldehydes, ketones and carboxylic acid derivatives with hydrides-Reduction with N_2H_4 and N_2H_2, Wolff-Kishner type reduction, Barton olefin synthesis, McMurry coupling, Pinacol coupling, General consideration on the selectivity of common reagents for reduction.	14	5, 6, 7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brainstorming lecture, Explicit Teaching, E-learning, **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – One MCQ based and one extended answer type • Book review – every student to review a seminal work on Alternative Education and submit a report • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar • Field visit report – each student shall individually or in a group visit an institution with demonstrated experience of alternative thoughts and prepare a report **B. Semester End examination**

REFERENCES

1. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry Part A, Springer, 2007
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B, Springer, 2007
3. H. O. House, W. A. Benjamin, Modern Synthetic Reactions, 2nd Edn. Inc, Mento Park, 1972.
4. J. March, Advanced Organic Chemistry, 4th Edn. Wiley India, New Delhi, 2005
5. R O C Norman, J. M. Coxon, Principles of Organic Synthesis, 3rd Edn. Blackie Academic, 1993
6. M. Fieser, J. G. Smith, Reagents for Organic Synthesis Wiley New York, 1988, All volumes
7. M. Hudlicky, Oxidations in Organic Chemistry American Chemical Society, 1990
8. M. Hudlicky, Reductions in Organic Chemistry, Ellis Horwood, 1986

SUGGESTED READINGS

1. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, Oxford University Press, 2014

	MAHATMA GANDHI UNIVERSITY
	CSM21C21 Organometallic Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Organometallic Chemistry**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C21**					
Course Summary & Justification	This course introduces the basic concepts of organometallic chemistry with an emphasis on transition metal complexes. The students will understand the structure and bonding of organometallic complexes bearing various σ-bonded and π-bonded ligands. They will learn about the unique reactions shown by organometallic compounds and their mechanism. This course highlights the application of organometallics in catalysis which is industrially important.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge of Inorganic Chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the fundamental concepts of organometallic complexes such as the 18-electron rule.	U	1
2	Explain and rationalize the structure and bonding of organometallic compounds with σ- and π-bonded ligands	U	1
3	Apply spectroscopic techniques to characterize organometallic compounds	A	2, 7
4	Identify the fundamental reactions of organometallic compounds and their mechanism.	An	3
5	Describe the application of organometallics in catalysis	A	3, 7
6	Design new organometallic complexes that have application in catalysis.	C	6, 7

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT	Hours	CO No.
Unit 1: Introduction to Organometallic Chemistry Content for Classroom Transaction (Sub-units) 1.1. Classification and nomenclature 1.2. Concept of hapticity 1.3. Structure prediction based on 18-electron rule 1.4. 16-electron compounds	5	1
Unit 2- Structure and bonding in organometallics Content for Classroom Transaction (Sub-units) 2.1. Synthesis, structure, bonding and IR spectra of metal carbonyls 2.2. Carbonylate ions 2.3. Carbonyl Hydride Complexe 2.4. Polynuclear carbonyls 2.5. Metal nitrosyls 2.6. Metal cyanides 2.7. Metal phosphines and biphosphines 2.8. Metal dioxygen and dinitrogen complexes	10	1, 2
Unit 3: Organometallic Compounds of Linear and Cyclic π-Systems and characterization of these compounds using spectroscopic techniques Content for Classroom Transaction (Sub-units) 3.1. Structure and bonding of complexes with chain pi-donor ligands: olefins, acetylenes, pi-allyl complexes 3.2. Metal-carbenes and metal-carbynes 3.3. Structure and bonding of complexes with cyclic pi-donors: cyclobutadiene, cyclopentadiene, benzene, cycloheptatriene and cyclooctatetraene 3.4. Structure, bonding and reactions of ferrocene 3.5. Metallocenes -Sandwich and half-sandwich compounds 3.6. Stereochemically non-rigid molecules 3.7. Fluxionality in organometallic compounds and characterization using NMR spectroscopy	12	2, 3
Unit 4: Metal Clusters Content for Classroom Transaction (Sub-units) 4.1. Di-nuclear clusters 4.2. Multinuclear clusters: low and high nuclearity clusters 4.3. Electron counting schemes of multinuclear carbonyl clusters 4.4. Capping rules 4.5. The isolobal concept 4.6. Structural prediction of organometallic clusters	10	2

Unit 5: Reactions of Organometallic Complexes Content for Classroom Transaction (Sub-units) 5.1. Ligand substitution reactions in organometallic complexes 5.2. Oxidative addition and reductive elimination reactions 5.3. Migratory insertion reactions: 1,1-migratory insertion reaction and 1.2-insertion 5.4. β-hydride elimination reactions 5.5. Cyclometallation reactions, orthometallation, oxidative coupling and metallacycles 5.6. Nucleophilic attack of coordinated ligands	10	4
Unit 6: Catalysis by Organometallic Compounds Content for Classroom Transaction (Sub-units) 6.1. Alkene hydrogenation (Wilkinson's catalyst) 6.2. Monsanto process 6.3. Water-gas shift reaction 6.4. Hydro-formylation reactions 6.5. Wacker process 6.6. Ziegler-Natta polymerization of alkenes 6.7. Fischer-Tropsch process 6.8. Alkene metathesis 6.9. Oligomerisation of alkenes and alkynes	10	4, 5
Unit 7: Applications of Organometallic Chemistry Content for Classroom Transaction (Sub-units) 7.1. Organometallics in the industry 7.2. Organometallics in medicine-drugs, radiopharmaceuticals, tracers 7.3. Organometallics in agriculture 7.4. Organometallics in environmental science	3	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar/ Presentation by individual student, Assignments, Authentic learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – MCQ based and descriptive answer type • Seminar Presentation – the students will be given individual topics for seminar presentation • Assignments • Quizzes **B. Semester End examination**

REFERENCES

1. R. H. Crabtree, The organometallic Chemistry of Transition Metals, 4th Edn. John Wiley, 2005.
2. J. P. Collman, L. G. Hegedus, J. R. Norton, R. G. Finke. Principles and Applications of Organotransition Metal Chemistry, Oxford University Press, 2nd Edn.

3. J. E. Huheey. R. A. Keiter, R. L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn. Prentice Hall, 1997.
4. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th Edn. Wiley-Interscience, 1999.
5. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver and Atkins, Inorganic Chemistry, 4th Edn. Oxford University Press, 2006.
6. J. D. Atwood, Inorganic and Organometallic Reaction Mechanism, Wiley-VCH, 1997.
7. E. Douglas, D. H. McDaniel, J. J. Alexander. Concepts and Models of Inorganic Chemistry, 3rd Edn. Wiley-India, 2007.
8. M. Bochmann, Organometallics and Catalysis: An Introduction, Oxford University Press, 2014.
9. W. K. Li, G. D. Zhou, T. Mak, Advanced Structural Inorganic Chemistry, Oxford University Press, 2008.
10. D. Gupta, A. J. Elias, Basis Organometallic Chemistry, Universities Press, 2013.

	MAHATMA GANDHI UNIVERSITY
	CSM21C22 Analytical and Nuclear Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Analytical and Nuclear Chemistry**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C22**					
Course Summary & Justification	This course essentially encompasses two components. The first component is the advanced course materials on general analytical chemistry instruments, operation, sampling and their applications. Here some modern instruments which work under the principle of fluorescence are discussed to get an understanding of the present and future applications of these fluorescence microscopes in the field of medicine. In addition, a concise discussion on specific sampling methods and titrations in non-aqueous media is also included as an application of analytical chemistry. In the second part, nuclear reactions are discussed with an emphasis on nuclear activation techniques, light-initiated and heat-initiated reactions and their different outcome. Most common and complex nuclear interactions with matter are discussed to get an understanding of the synthetic utility of this technique while designing such processes. A special emphasis is given to the importance of nuclear medicine owing to its importance in cancer research, towards the end of the discussion. Therefore, the second part gives advanced know-how on nuclear chemistry with an added stress on procedure and applications of nuclear radiation in the medical field.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Hours
	Others include Research, fieldwork, Independent Learning, etc.	40	40	0	40	120
Credit Value & Course Status	3	Core Course				
Pre-requisite	Basic Inorganic Chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the methods used in sampling for various analytical methods.	U	1
2	Learn about the general instrumentation in thermal analysis, chromatography and microscopy	U	1, 2
3	Identify the utility and specificity of each analytical instrument and will be in a position to generate and explain the output data from the analytical instruments.	An	1, 2, 3,7
4	Critically understand the nuclear reactions, methods of detection and quantification, the scope and limitations of nuclear reactions	U	1, 2, 3
5	Evaluate the utility of fluorescence spectroscopy and nuclear radiation therapy for qualitative and quantitative methods of analysis, particularly in medicine.	E	1, 2, 3, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Sample Analysis Content for Classroom Transaction (Sub-units) 1.1. Preparation of sample for analysis 1.2. Errors and treatment of data	5	1, 3, 4, 5
Unit 2: Solubility Content for Classroom Transaction (Sub-units) 2.1. Solubility and solubility product 2.2. Common ion effect 2.3. Precipitation phenomena 2.4. Homogeneous precipitation 2.5. Organic reagents in inorganic analysis	8	1, 3, 4, 5
Unit 3: Titrations in Non-aquesous Media Content for Classroom Transaction (Sub-units) 3.1. Titrations in non-aqueous media 3.2. Potentiometry 3.3. Polarography 3.4. Amperometry 3.5. Bi-amperometry 3.6. Spectrophotometry 3.7. Flame photometry 3.8. Atomic absorption spectroscopy	10	1-5
Unit 4: Ion Exchange Content for Classroom Transaction (Sub-units) 4.1. Principles of ion-exchange 4.2. Solvent extraction 4.3. Chromatographic techniques	4	1, 2

Unit 5: Thermal Methods of Analysis **Content for Classroom Transaction (Sub-units)** 5.1. Thermal method of analysis 5.2. Principles and applications of thermogravimetry (TG) 5.3. Differential thermal analysis (DTA) 5.4. Differential scanning calorimetry (DSC) 5.5. Dynamic mechanical analysis (DMA)	8	1, 2, 4, 5
Unit 6: Applications of X-Ray Diffraction **Content for Classroom Transaction (Sub-units)** 6.1. Applications of X-ray diffraction 6.2. Small angle X-ray scattering (SAXS), 6.3. Scanning electron microscopy (SEM), 6.4. Transmission electron Microscopy (TEM) 6.5. Scanning probe microscopy (SPM)	8	1, 2, 4, 5
Unit 7: Nuclear Chemistry **Content for Classroom Transaction (Sub-units)** 7.1. Nuclear reactions fission and fusion 7.2. Spontaneous and induced fission 7.3. Q-value 7.4. Cross sections 7.5. Working of nuclear reactors 7.6. Fission energy 7.7. Transuranics 7.8. Applications of radioactivity 7.9. Carbon dating	10	1-5
Unit 8: Radioactive Techniques **Content for Classroom Transaction (Sub-units)** 8.1. Neutron activation analysis 8.2. Tracer techniques 8.3. GM counter 8.4. Interaction of high energy radiation with matter 8.5. Radiation chemistry of water 8.6. Aqueous solutions and organic compounds	7	1, 2, 5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar/ Presentation by individual student, Assignments, Authentic learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – MCQ based and descriptive answer type • Seminar Presentation – the students will be given individual topics for seminar presentation • Assignments • Quizzes **B. Semester End examination**

REFERENCES

1. I. Vogel, J. Mendhan, Vogel's Texbook of Quantitative Inorganic Analysis, 6th Edn. Prentice Hall, 2000.
2. A. Skoog, D. M. West, F.J. Holler, Fundamentals of Analytical Chemistry, 7th Edn. Sauders College, 1996.
3. W. W. Wendlandt, Thermal Analysis, 3rd Edn. Wiley, 1986.
4. G. Cao, Y. Wang, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific, 2010.
5. H. R. Arnikor, Essentials of Nuclear Chemistry, Wiley- Eastern, 1983.

	MAHATMA GANDHI UNIVERSITY
	CSM21C23 Chemical Kinetics

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Chemical Kinetics**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C23**					
Course Summary & Justification	In chemical kinetics, the students will learn the rate laws of chemical transformations, and experimental methods of determining the rate of a reaction. Also, they will be able to understand different types of Complex reactions and Application of the method of integration, Differential method, Half-life method and Graphical method to solve for the concentration of chemical species during a reaction of different orders. After completion of this course, the students will be able to understand the collision frequency, kinetic energy and orientation of colliding reactant molecules affect the rate of a chemical reaction and also, explain how enzymes act as biological catalysts and how they interact with specific substrate molecules.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	1. The concept of reaction rates 2. General form of the rate law for any chemical reaction 3. The relationship between the order of a reactant and the stoichiometric coefficient for the reactant in the overall balanced chemical equation. 4. How the order of each reactant appearing in the rate law is determined 5. Distinguish between instantaneous rates and average rates					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	After Completion of this course, the student should be able to; Understand the concept of rate of change associated with chemical change, recognizing that the rate of change and how it can be measured	U	1, 2, 3
2	Identify the reaction order for a chemical change	S	3 ,4, 5
3	Recognize the integrated rate laws and evaluate the order of the reaction from plots of concentration versus time, ln(concentration) versus time, and 1/(concentration) versus time	Ap	5, 6, 7
4	Apply integrated rate equations to solve for the concentration of chemical species during a reaction of different orders	A	1, 2, 3, 5
5	Analyses and explain how enzymes act as biological catalysts and how they interact with specific substrate molecules.	U	5, 6, 7
6	Interpret potential energy profiles and use them to determine the activation energy and potential energy changes for a reaction.	C	1, 2, 3, 6
7	Understand the differences between the kinetics of reactions in the gas phase, compared with those in liquid solutions	U	3, 4, 5, 6
8	Evaluate and explain the distinction between diffusion-control and activation control of reaction rates in solutions	E	5, 6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Introduction to Chemical Reaction Kinetics Content for Classroom Transaction (Sub-units) 1.1. Reaction rates and order of reactions, determination of the order of reactions 1.2. Complex reactions (Free radical chain reactions, branching reactions, hydrogen-oxygen and Hydrogen –Halogen reactions.) 1.3. Reversible, consecutive and opposing reactions 1.4. The Analysis of kinetics results: the method of integration, Graphical methods, half-life methods, Guggenhiem's method, and the differential method. 1.5. Reactions of variable order- steady-state treatment, free radical reactions-the Rice Herzfeld Mechanism. 1.6. Studies of fast reactions by flow method, Relaxation method and flash photolysis 1.7. Theories of unimolecular reaction and their treatments (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus (RRKM) theory.	14	1, 2, 3, 8

Unit 2: Reaction Dynamics Content for Classroom Transaction (Sub-units) 2.1. Collision theories of reaction rates, steric factor 2.2. Arrhenius equation, activated complex theory, Collision cross section and reaction cross-section 2.3. Collision theory. Potential energy surfaces and reaction coordinate 2.4. Transition state theory 2.5. Comparative study of the theories of reaction rates 2.6. Thermodynamic treatment of Reaction rates. 2.7. Kinetic theory of gases, Transport properties in gases	16	3, 4, 6
Unit 3: Kinetics of reactions in solution 3.1. Diffusion controlled reactions 3.2. Effect of solvent on rates of reactions 3.3. Ionic reactions and effect of ionic strength 3.4. Kinetic Salt effect 3.5. Dynamics of barrier-less chemical reactions in solutions 3.6. Effect of pressure on the velocity of gas reactions 3.7. Homogeneous catalysis and Heterogeneous catalysis 3.8. Enzyme kinetics-Enzyme catalysis and its mechanism, Michelis – Menten equation, the effect of pH and temperature on enzyme catalysis 3.9. Surface phenomena and physical methods for studying surfaces	16	4, 5, 7
Unit 4: Kinetics of Polymerisation 4.1. cationic and anionic reactions 4.2. explanation of copolymerization in terms of kinetics 4.3. copolymerization equation	14	1, 8

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning, interactive sessions **Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Seminar and Group discussion.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – on extended answer type • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar **B. Semester End examination**

REFERENCES

1. K. J. Laidler, Chemical Kinetics, 4th Edn. Harper & Row,
2. P. J. Flory, Principles of polymer Science, Cornel University

	MAHATMA GANDHI UNIVERSITY
	CSM21C26 Advanced Organic Synthesis

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Advanced Organic Synthesis**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C26**					
Course Summary & Justification	In this course, in addition to learning some new reactions and concepts in organic synthesis, the reactions learned in the previous semesters are applied, especially to complex organic molecules. This course enables the student to independently analyse a synthetic problem and arrive at a viable solution. Also equips the student to bring forth a plausible synthetic route to complex organic molecules of importance. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences. This course is designed to provide students with a comprehensive understanding of organic reactions and their applications. This knowledge will enable the students to come up with synthetic strategies for organic transformations as well as equip them to design synthetic routes for complex organic molecules of natural and unnatural origin.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	SCSMPC07 Stereochemistry and Conformations of Organic Compounds SCSMPC17 Reactions and Reagents in Organic Synthesis					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Acquires the ability to do chemical transformations.	U	1
2	Acquires the skill to propose the mechanism of reactions.	U	3
3	Equip the students to synthesize complex natural and unnatural compounds of importance by practicing retrosynthetic analysis.	A	4

4	Acquires the knowledge to transform molecules using functional group interconversions.	A	5, 7
5	Work in the interdisciplinary and multidisciplinary areas of chemical sciences and its applications.	A	6
6	Be able to work productively and collaboratively as a team member by solving problems with other students.	S	5
7	Provide students with the skills required to succeed in Master program and enrich them with basic skills to perform in the R & D chemical industrial level.	A	6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Organometallics Application of organo-transition metal complexes in Organic synthesis with special reference to organopalladium chemistry-Heck reaction, Stille coupling, Kumada coupling, Suzuki coupling, Negishi coupling, Hiyama coupling, Sonogashira coupling and Cadiot-Chodkiewicz reaction.	8	1, 2
Unit 2: Protection and Deprotection Protection, activation and deprotection process in organic synthesis, Protection and deprotection of hydroxyl, carboxyl, carbonyl and amino groups.	12	1, 3, 4
Unit 3: Reactions and reagents in organic synthesis Macrolactonization, Mitsunobu reaction, Metallocarbenes, Metathesis reactions, Different types of metathesis reactions, Grubb and Schrock catalysts.	10	3, 4
Unit 4: Multicomponent reactions (MCR) and Combinatorial chemistry Survey of multicomponent reactions-Passerini-Ugi-Biginelli-Introduction to Combinatorial chemistry	6	2
Unit 5: Name reactions in organic synthesis Bamberger, Baylis-Hillman, Bergmann, Buchwald-Hartwig, Click, Dakin, Demjanov, Di-pi-methane, 1,3-dipolar, Mannich, Michael, Nazarov, Neber, Nef, Noyori, N-H-K, Pauson-Khand, Pechmann, Ritter, Sakurai, Shapiro, Stobbe, Tebbe and Vilsmeier reactions.	12	2, 4, 5, 6
Unit 6: Rearrangement reactions Beckmann, Benzilic acid, Claisen, Curtius, Dienone-Phenol, Favorskii, Fischer-Hepp, Fries, Hoffmann, Lossen, Orton, Schmidt, Smiles, Sommelet-Hauser, Stevens, Von Richter, Wagner-Meerwein, Wittig and Wolff rearrangements.	12	4, 5 ,6, 7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brain storming lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – One MCQ based and on extended answer type • Book review – every student to review a seminal work on Alternative Education and submit a report • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar • Field visit report – each student shall individually or in group visit an institution with demonstrated experience of alternative thoughts and prepare a report **B. Semester End examination**

REFERENCES

1. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry Part B, 5th Edn. Springer, 2007
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 2nd Edn. John Wiley, 1994
3. T. W. Greene, P. G. M. Wuts, Protective Groups in Organic Synthesis, John Wiley, 1999
4. J. Zhu, H. Bienayme, Multicomponent Reactions, Wiley VCH, Weinheim 2005
5. L. Kurti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press 2005

SUGGESTED READINGS

1. J. Fuhrhop, G. Penzlin, Organic Synthesis, VCH Weinheim, 1994
2. K. C. Nicolaou, E. J. Sorensen, Classics in Total Synthesis, Wiley VCH Weinheim 1996
3. S. V. Bhat, B. A. Nagasampagi, M. Sivakumary, Chemistry of Natural Products, Narosa publishing New Delhi, 2005

	MAHATMA GANDHI UNIVERSITY
	CSM21C27 Organic Chemistry Lab- II

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Organic Chemistry Lab- II**					
Course Credit	**2**					
Type of Course	**CORE**					
Course Code	**CSM21C27**					
Course Summary & Justification	Students will learn how to apply common laboratory techniques to determine the structure and the chemical properties of organic compounds They will become familiar with the nomenclature and behavior of organic functional groups through reactions and instrumental analysis. Various reactions including nucleophilic substitution, dehydration, and oxidation will be used to synthesize new compounds from starting materials.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	0	0	120	30	150
Pre-requisite	Basic knowledge in practical organic chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Able to perform experiments individually and gain knowledge about principles and techniques involved in various experiments	U	1
2	Acquire Experimental skills & handling instruments.	A	3
3	Gain Knowledge in Prediction & verification of Experimental results	Ap	2
4	To predict the mechanisms of different molecular rearrangements	An	2, 3, 6
5	Describe reaction mechanisms in terms of energetics, reaction kinetics, and thermodynamics.	U	6, 7
6	Correlate the reactivity of a compound with its structure.	C	6
7	Evaluate the yield of a particular product in a mixture under a set of conditions	E	4, 5

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT	**Hours**	**CO No**
Content for Laboratory Transaction (Sub-units) **Unit 1: Advanced multi-step synthesis of organic compounds** 1.1. Principles of organic synthesis 1.2. Various experimental methods	50	1-7
Unit 2: Characterisation of Compounds 2.1. Infra-Red Spectroscopy 2.2. NMR Spectroscopy 2.3. UV-Visible Spectroscopy	10	2-7
Unit 3: Isolation of Natural Products, Purification and characterisation 3.1. Thin Layer Chromatography 3.2. Column Chromatography 3.3. Steam distillation 3.4. Solvent Extraction 3.5. Soxhlet Extraction	60	1-7

Assessment Types	**Mode of Assessment** • Lab/Experiment skills • Lab record/Report • Viva-voce • Lab Discipline (participation, punctuality, accuracy)

REFERENCES

1. S. Furniss, A. J. Hannaford, V. Rogers, P. W. G. Smith, A. R. Tatchell, Vogel's Text Book of Practical Organic Chemistry, ELBS & Longman, London, 2005.
2. R. M. Silverstein, G. C. Bassler, T. C. Merril, Spectrometric Identification of Organic Compounds, John Wiley & Sons, 1981.
3. D. Pasto, C. R. Johnson, M. J. Miller, Experiments and Techniques in Organic Chemistry, Prentice Hall, 1992.

	MAHATMA GANDHI UNIVERSITY
	CSM21C35 Research Project and Seminar

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Research Project and Seminar**					
Course Credit	**9**					
Type of Course	**CORE**					
Course Code	**CSM21C35**					
Course Summary & Justification	The candidate shall give a seminar (30 minutes) on the research project submitted. This follows a discussion with the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Library work, lab work, Teamwork, independent learning	-	-	-	-	-
Pre-requisite						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course, the students are expected to		
1	To present and discuss the research objectives, methodology, analysis, results and conclusions effectively.	A	2-5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Gain deeper knowledge of methods in the topic of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6
7	Create, analyse and critically evaluate different problems and their solutions.	C	7
8	Gain a consciousness of the ethical aspects of research.	E	6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, Library work, laboratory work, Teamwork, independent learning and Group discussion, Presentation of research work.
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners.

	MAHATMA GANDHI UNIVERSITY
	CSM21C36 Comprehensive Viva-Voce

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Comprehensive Viva-Voce**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C36**					
Course Summary & Justification	The comprehensive viva-voce shall be conducted by the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner. A thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of chemical sciences are evaluated.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Classroom studies, lab work, library Library work, independent learning, etc.	-	-	-	-	-
Pre-requisite	Basic as well as in-depth knowledge in the courses he/she studied					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course, the students are expected to		
1	Achieve fundamental and in-depth knowledge	A	3
2	Acquire more in-depth knowledge of the major subject of study	Ap	1-7
3	Deeper knowledge of methods in the major subject of study.	A	1, 4
4	Able to contribute to research and development work.	U	3
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, Library work, laboratory work, Team work, independent learning and Group discussion, Presentation of research work
Assessment Types	**Mode of Assessment** Thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of chemical sciences are evaluated. The candidate will be asked questions based on the whole syllabus he/she studied in the entire programme. How he/she answered or responded the questions asked will be considered for evaluation.

	MAHATMA GANDHI UNIVERSITY
	CSM21C38 Advances in Organic Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Advances in Organic Chemistry**					
Course Credit	**3**					
Type of Course	**CORE**					
Course Code	**CSM21C38**					
Course Summary & Justification	In this course, the student learns some new topics such as medicinal chemistry, industrial organic chemistry, process chemistry and reticular chemistry. In addition, the student gets exposure to some top organic chemistry journals to learn methodology development and natural product synthesis. This course also trains the student to identify a research topic for review writing, write a review and submit to a journal. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences. This course is designed to provide students with a good understanding of some areas of applied organic chemistry. This knowledge will be very beneficial in medicinal chemistry, especially drug discovery.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	40	0	40	120
Pre-requisite	SCSMPC17 Reactions and Reagents in Organic Chemistry SCSMPC26 Advanced Organic Synthesis					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Acquires the ability to understand medicinal chemistry aspects.	U	1
2	Acquires the ability to understand aspects of heterocyclic chemistry.	U	3
3	Equip the students to design synthetic routes for complex organic molecules.	A	2, 3, 6, 7
4	Acquires the knowledge to propose an industrial route for organic molecules.	A	2

5	Work in the interdisciplinary and multidisciplinary areas of chemical sciences and its applications.	A	3, 4, 5
6	Be able to work productively and collaboratively as a team member by solving problems with other students.	S	5
7	Provide students with the skills required to succeed in master program and enrich them with a basic-skills to perform at R & D chemical industrial level.	A	2, 3
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Medicinal Chemistry Basic principles - IC50, LogP, LogD, MIC, Efficacy, Stages in drug discovery, Natural and Synthetic drugs, Basic knowledge on anti-bacterials, beta-lactam antibiotics, Opium analgesics, Anti-inflammatory drugs, NSAID, proton pump inhibitors, cardiovascular drugs, Sulfonamides, Chiral drugs.	14	1
Unit 2: Heterocycles Aromatic and nonaromatic heterocycles, Synthesis of heterocycles, basicity-Pyridines, quinolines, isoquinolines, pyrroles, furans, thiophenes, Indoles, pyrimidines, imidazoles, pyrazoles, aziridines. Fused heterocycles, Name reactions in heterocyclic chemistry-Bartoli, Corey-Chykovsky, Darzen, Jacobsen, Katzuki, Paterno-Buchi, Paal-Knorr pyrrole & furan, Fischer indole, Bischler-Napieralski, Pictet-Spengler Syntheses	16	2, 6, 7
Unit 3: Retrosynthetic analyses Comparison and selection of appropriate reactions-designing synthesis. Retrosynthetic analysis-Disconnection approach. One group, two groups and illogical disconnections. Functional group interconversion-Synthetic equivalent groups-Multistep synthesis -Convergent synthesis -Formation of C-C bonds, carbon-heteroatom bonds, Ring closure and ring-opening reactions	18	3, 5, 6, 7
Unit 4: Industrial Organic Chemistry Basic principles, Basic building block chemicals from fossil sources, Non-petroleum sources of organic chemicals (coals, fats & oils, Carbohydrates), Food additives, Catalysis in industrial organic chemistry.	14	4, 6, 7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brainstorming lecture, Explicit Teaching, E-learning, **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – One MCQ based and on extended answer type • Book review – every student to review a seminal work on Alternative Education and submit a report

	• Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar • Field visit report – each student shall individually or in a group visit an institution with demonstrated experience of alternative thoughts and prepare a report **B. Semester End examination**

REFERENCES

1. G. L. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, 1995
2. G. Thomas, Fundamentals of Medicinal Chemistry Wiley, 2003
3. T. L. Gilchrist, Heterocyclic Chemistry, 3rd Edn. Dorling Kindersley publication, 2007
4. S. Warren, Organic Synthesis-A Disconnection Approach, John Wiley, 1985
5. H. A. Wittcoff, B. G. Reuben, J. S. Plotkin, Industrial Organic Chemicals, Wiley-interscience, New Jersey, 2004.
6. H-J. Arpe, Industrial Organic Chemistry, Wiley-VCH, Weinheim, Germany, 2010.

SUGGESTED READINGS

1. X-T. Liang, W-S. Fang, Medicinal Chemistry of Bioactive Natural Products, Wiley interscience, 2006
2. A. Kar, Medicinal Chemistry, 3rd Edn. New age international publishers New Delhi, 2005
3. J. A. Joule, G. F. Smith, Heterocyclic Chemistry, 2nd Edn. Chapman and Hall, 1990
4. J. J. Li, Name Reactions in Heterocyclic Chemistry, Wiley interscience, 2005
5. J. Fuhrhop, G. Penzlin, Organic Synthesis: VCH, Weinheim, 1994

	MAHATMA GANDHI UNIVERSITY
	CSM21E41 Equilibrium Statistical Mechanics

School Name	**School of Chemical Sciences**
Programme	**M.Sc.**
Course Name	**Equilibrium Statistical Mechanics**
Course Credit	**2**
Type of Course	**ELECTIVE**
Course Code	**CSM21E41**
Course Summary & Justification	Equilibrium Statistical mechanics provides a theoretical bridge that takes you from the micro world to the macro world. This attempts to derive the macroscopic properties of an object from the properties of its microscopic constituents and the interactions amongst them. It tries to provide a theoretical basis for empirical thermodynamics. This course is designed at providing students with basic concepts of calculating properties of an energetically isolated system in equilibrium by imposing probability distribution over the set of microscopic states compatible with the external constraints imposed on the system. Using this probability distribution, average values of specified functions of the microscopic conditions of the gas can be calculated. From this course, students will be able to understand what probability distribution means, why average values for macroscopic conditions, and how phase averages related to measured features of the macroscopic system, etc. And also helps the students to analyse how changing quantum mechanical basis leads to wholesale changes within statistical mechanics. Bose-Einstein statistics, Fermi Dirac statistics and Maxwell Boltzmann statistics will be discussed. Students will be able to calculate thermodynamic properties (U, H, S, A, G) and equilibrium constant (K). This course helps students to *predict the* heat capacity (C_P, C_V) of an ideal gas from the number of degrees of freedom, rotational and vibrational wave numbers. Moreover, students can explain T^3 dependence of heat capacities at low temperatures of solids using Debye and Einstein theory of heat capacity of solids. Students will *understand* the concept of phonons. Also, students will be able to explain Fermi energy and the Free electron model of metals and use it to solve problems. Further, students will gain deep knowledge of photon gas.

Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100

Pre-requisite	Basics of Thermodynamics, Quantum dynamics and Probability theory. This is based on statistical methods, probability theory and microscopic physical laws. It can be used to explain the thermodynamic behaviour of large systems.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Basic knowledge of Thermodynamics	U	1
2	Understand the inadequacy of Quantum dynamics and Probability theory	U	1, 2
3	Identify the statistical methods and microscopic physical laws.	R	1, 6
4	Analysis of probability theory and problem-solving	E	1, 3, 6,
5	Applying the principles of statistical thermodynamics can calculate the thermodynamic properties and equilibrium constant (K) of large systems.	A	1, 2
6	Explain T^3 dependence of heat capacities of solids	U	1, 2
7	Explain the Fermi energy and Free electron model of metals and use it to solve problems	A	1, 4,
8	Explain photon gas and phonon gas	U	1, 4, 7
Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Mathematical preliminaries Content for Classroom Transaction (Sub-units) 1.1. Elementary combinatorics 1.2. Stirling's approximation 1.3. Method of Lagrange multipliers 1.4. Introduction to probability 1.5. Gamma functions 1.6. Power series method	5	2, 4
Unit 2: Physics preliminaries Content for Classroom Transaction (Sub-units) 2.1. Classical mechanics 2.1.1 Newtonian, Lagrangian and Hamiltonian approaches to mechanics. 2.2. Quantum Mechanics 2.2.1 Hydrogen atom, rigid rotor and harmonic oscillator	3	1, 2
Unit 3: Classical and quantum statistics Content for Classroom Transaction (Sub-units) 3.1. Bose-Einstein statistics 3.2. Fermi Dirac statistics 3.3. Maxwell Boltzmann statistics	3	3

Unit 4: Ensemble theory Content for Classroom Transaction (Sub-units) 4.1. Gibb's hypothesis 4.2. Concept of phase space 4.3. Postulate of equal apriori probabilities 4.4. Ensemble averages 4.5. Partition function	4	3, 5
Unit 5: Canonical ensemble Content for Classroom Transaction (Sub-units) 5.1. Evaluation of undetermined Lagrange multipliers 5.2. Boltzmann's hypothesis	3	3, 5
Unit 6: Other ensembles Content for Classroom Transaction (Sub-units) 6.1. Micro canonical ensemble 6.2. Grand canonical ensemble	2	3, 5
Unit 7: Ideal gas Content for Classroom Transaction (Sub-units) 7.1. Derivation of PV= nRT from first principles 7.2. Expressions for heat capacity at constant volume and constant pressure	3	3, 5
Unit 8: Molecular interactions in liquids Content for Classroom Transaction (Sub-units) 8.1. Radial distribution function g(r) 8.2. Calculation of g(r) using Monte Carlo method 8.3. Calculation of g(r) using molecular dynamics approach	4	3, 5
Unit 9: Chemical equilibrium Content for Classroom Transaction (Sub-units) 9.1. Connection between the equilibrium constant of gas phase reactions and the canonical partition function	3	3, 5
Unit 10: Solids Content for Classroom Transaction (Sub-units) 10.1. Einstein and Debye theory of solids. 10.2. Phonons	5	6
Unit 11: Metals and Photons Content for Classroom Transaction (Sub-units) 11.1. Fermi function and Fermi energy. 11.2. Free electron model and density of states. 11.3. An ideal gas of photons (black body radiation	5	7, 8

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminars, Assignments Seminars, Authentic learning, Library work, independent studies Presentation by individual students. Computational lab

Assessment Types	Mode of Assessment
	A. Continuous Internal Assessment (CIA) • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

References

1. A. McQuarrie, Statistical Mechanics, University Science Books, 2000.
2. K. Huang, Statistical Mechanics, 2nd Edn. John Wiley and Sons, New York. 1987.
3. B. Widom, Statistical Mechanics - A Concise Introduction for Chemists, Cambridge, University Press, 2002.
4. P. Atkins, J. De Paula, Atkins' Physical Chemistry, 9th Edn. Oxford University Press, Oxford, 2010.
5. W. Feller, Introduction to Probability and its applications, 2nd Edn. John Wiley 2008.
6. D. Stirzaker, Elementary Probability, Cambridge University Press, Cambridge, 1994.

	MAHATMA GANDHI UNIVERSITY
	CSM21E42 Introduction to Polymer Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Introduction to Polymer Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E42**					
Course Summary& Justification	Polymer chemistry is a distinctive topic in chemistry having many inter as well as multidisciplinary components. This course is designed as an interdisciplinary course that includes fundamental as well as in-depth knowledge of polymer science. The syllabus has been designed to cover the fundamental understanding of different fields of polymer chemistry with special emphasis on polymer synthesis and related topics thereby enabling the students to work in frontier areas of polymer sciences. This comprises the history of polymer science and its relevance in the development of human civilization. The syllabus covers the significance of polymer molecular weight and its relation to the structure and property of various polymers. This course also covers a detailed study of polymerisation types and techniques for polymer synthesis. Finally, an idea about the thermodynamics and kinetics of polymerization followed by copolymerization kinetics is discussed. This course further offers awareness and understanding of the contemporary trends and growth in the field of polymer science. After the completion of this course, students will be able to understand the basics associated with polymer materials and the method/mechanism of its synthesis.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include Group discussions, Seminars, Independent Learning, etc.	40	0	0	60	100
Pre-requisite	Nil					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	To Acquire sound knowledge of the fundamentals and importance of Polymer chemistry	R, U	1, 3, 6
2	*To understand the peculiarities of polymer molecular weight* and various determination techniques	U, A	1, 4, 5
3	To Correlate the structure, property relationship in polymeric materials for various applications	An	1, 2, 3, 6
4	To outline the basic concepts of Tg, crystallinity and polymer morphology	U, A	1, 2, 4
5	To compare and correlate various polymerization methods and techniques including advanced approaches	U, A, An	1, 2, 4, 7
6	To outline the mechanism and kinetics of polymerizations including co-polymer equation	An, E	1, 2, 6, 7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT	Hours	CO No
Unit 1: Fundamentals of polymer & macromolecule Content for classroom transaction 1.1. Concept of polymer & macromolecules 1.2. Definition, classification, functionality 1.3. Methods of polymerization, 1.4. Polydispersity conformation and configuration of macro-molecules stereo isomerism and tactility in polymers	5	1, 4
Unit 2: Polymer structure and properties Content for classroom transaction (Sub-units) 2.1. Crystalline and amorphous polymers 2.2. Crystallinity 2.3. Basic determinants of polymer properties 2.4. Polymer chain flexibility. Factors affecting chain flexibility	5	1, 3, 4
Unit 3: Polymer Molecular weights Content for classroom transaction (Sub-units) 3.1. Molecular weights and molecular weight averages 3.2. Molecular weight distribution, molecular weight distribution curve, integral and differential distribution curve 3.3. Methods of molecular weight determination-end group analysis, colligative property measurements, light scattering, ultra-centrifugation, viscometry, etc. 3.4. Fractionation of polymers, GPC	7	1, 2, 3
Unit 4: Thermal transitions in polymers Content for classroom transaction (Sub-units) 4.1. Glass transition temperature and crystalline melting points-Definition 4.2. Factors affecting Glass transition temperature 4.3. Methods to determine Tg, DSC, DTA, etc	3	4

Unit 5: Synthesis and techniques of Polymerization Content for classroom transaction (Sub-units) 5.1. Condensation and addition polymerization, Chemistry of monomeric units. 5.2. Polymerization techniques: solution, bulk, emulsion polymerizations, melt and interfacial polycondensations methods 5.3. ring opening polymerization, Group transfer polymerization, Photochemical polymerization 5.4. Advanced polymerization methods such as RAFT, ATRP, etc	7	5
Unit 6: Mechanism and kinetics of polymerisation reactions Content for classroom transaction (Sub-units) 6.1. Mechanism and kinetics of polyaddition reactions, initiated by radical cationic and anionic means, living polymers. 6.2. Coordination polymerization, Ziegler Natta polymerization 6.3. Step reaction polymerization and its mechanism, kinetics of linear stoichiometric polycondensation 6.4. Carothers equation, number distribution and weight distribution functions, polyfunctional step reaction polymerization (non-linear poly condensation), branching in condensation polymerisation, gelation, prediction of gel point 6.5. Steady-state kinetics, degree of polymerization and chain transfer, chain termination, thermodynamics of polymerization	9	6
Unit 7: Co-polymerization Content for classroom transaction (Sub-units) 7.1. Simultaneous polymerization of more than one monomer, random, graft and block copolymers 7.2. Copolymerization equation	3	6

Teaching and Learning Approach	**Classroom Procedure (mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (40%)** • Internal Tests • Assignments • Seminar Presentation • Review Report **B. End Semester Examination (60%)**

References

1. V.R. Gowariker, N.V. Viswanathan, J. Sreedhar, Polymer Science, New Age International, 2010

Suggested Reading

1. G. G. Odian, Principles of Polymerization, 4th Edn. John Wiley & Sons, 2004.
2. K. J. Saunders, Organic Polymer Chemistry, 2nd Edn. Chapmann& Hall 1988.
3. K. Matyjaszewski, T. P. Davis, Handbook of Radical Polymerization, Wiley-Interscience, 2002.

4. P. J. Flory, Principles of Polymer Chemistry, Cornel University Press. London, 1953.
5. F. W. Billmeyer, Text Book of Polymer Science, Wiley interscience, 1976.
6. H. R. Allock, F. W. Lampe. Contemporary Polymer Chemistry. Prentice hall, 1981.
7. J. M. G. Cowie, V. Arrighi, Polymers: Chemistry & Physics of Modern Materials, 3rd Edn. CRC Press, 2008.

	MAHATMA GANDHI UNIVERSITY
	CSM21E43 Supramolecular Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Supramolecular Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM2 E43**					
Course Summary and Justification	This course essentially encompasses the basics and applications of supramolecular chemistry at the chemistry-biology interface. After completion of this course, the student will get an idea about this new branch of chemistry. Here the molecules are organized by weak forces of attraction in general called "non-covalent interactions". These kinds of complex molecular assemblies have great significance in the biology of life. Every biological reaction takes place by the formation and destruction of such supramolecular assemblies. That is why the biological reactions in general occur in an out-of-equilibrium situation. The student will understand the recognition process in biology starting from the very basic host-guest interactions.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Hours
	Others include Research, fieldwork, Independent Learning etc.	40	0	0	60	100
Credit Value & Course Status	2	Elective Course				
Pre-requisite	Basics of quantum mechanics, analytical solutions of Schrodinger eqaution in calculating the energy of atoms and molecules					

COURSE OUTCOMES (CO)			
CO No.	**Expected Course Outcome**	**Learning Domains**	**PSO No.**
1	After Completion of this course, the student should be able to; Understand the general concepts and definition of supramolecular chemistry and its importance at the chemistry-biology interface	R	1
2	Apply the basic principles of supramolecular chemistry to understand biological reactions respiration, neuron signalling, protein synthesis, DNA replication, photosynthesis etc.	A	2, 3
3	Distinguish and synthesize cation binding host molecules	An	7
4	Distinguish and synthesize anion binding host molecules	An	7
5	Distinguish and synthesize neutral molecule binding host molecules	C	7
6	Understand the design and synthesis of molecular robots/machines for various applications for instance in developing artificial intelligence	S	4. 6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Definition and development of supramolecular chemistry Content for classroom transaction (Sub-units) 1.1. Classifications of supramolecular host-guest compounds 1.2. Receptors, coordination and the lock and key analogy 1.3. The chelate and macrocyclic effects 1.4. Preorganization and complementarity 1.5. Thermodynamic and kinetic stability 1.6. Nature of supramolecular interactions	10	1
Unit 2: Supramolecular chemistry of life Content for classroom transaction (Sub-units) 2.1. Alkali-metal cations in biochemistry 2.2. Porphyrins and tetrapyrrole macrocycles 2.3. Supramolecular features of plant photosynthesis 2.4. Uptake and transport of oxygen by haemoglobin 2.5. Coenzyme B12 2.6. Neurotransmitters 2.7. Hormones 2.8. DNA	7	2
Unit 3: Cation binding hosts 3.1. The crown ethers 3.2. Lariat ethers and podands, cryptands 3.3. The spherands 3.4. Nomenclature, solution behaviour, selectivity of cation complexation 3.5. The macrocyclic, macro bicyclic and template effects 3.6. Soft ligands for soft metal ions 3.7. Complexation of organic cations 3.8. The calixarenes 3.9. The siderophores	5	3
Unit 4: Binding of anions Content for classroom transaction (Sub-units) 4.1. Biological anion receptors 4.2. Concepts in anion host design 4.3. From cation hosts to anion hosts-a simple change in pH 4.4. Guanidinium-based receptors 4.5. Organometallic receptors 4.6. Neutral receptors 4.7. Anticrowns	5	4
Unit 5: Binding of neutral molecules Content for classroom transaction (Sub-units) 5.1. Inorganic solid-state clathrate compounds 5.2. Solid-state clatharates of organic hosts 5.3. Intractivity complexes of neutral molecules 5.4. Solution and solid-state binding 5.5. Supramolecular chemistry of the fullerenes	5	5

Unit 6: Templates and self-assembly Content for classroom transaction (Sub-units) 6.1. Kinetics and thermodynamic considerations 6.2. Self-assembling of coordination compounds 6.3. Self-assembly of closed complexes by hydrogen bonding 6.4. Catenanes and rotaxanes 6.5. Self-assembly in biochemical and synthetic systems 6.6. Helicates 6.7. Molecular knots 6.8. Catalytic and self-replicating systems	8	6

Teaching and Learning Approach	**Learning Approach Consists of** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment** • Internal Tests • Assignments • Seminar • Performance during tutorial • Internal examination/ Viva voce **B. End Semester Examination**

References

1. J. W. Steed, J. L. Atwood, Supramolecular Chemistry, John Wiley and Sons, 2000

Suggested Reading

1. H. Dodziuk, Introduction to Supramolecular Chemistry, Springer,2001.
2. F. Vogtle, E. Webner, Host Guest Complex Chemistry: Macrocycles: Synthesis, Structures, applications, 2nd Edn. Springer,1985
3. P. D. Beer, P. A. Gale, D. K. Smith, Supramolecular Chemistry, Oxford University Press,1999.
4. K. Ariga, T. Kunitake, Supramolecular Chemistry: Fundamentals and Applications, Springer, 2006
5. J. M. Lehn, Supramolecular Chemistry: Concepts and Perspectives. John Wiley publications, 1995
6. S. Ranganathan, Patterns for Supramolecular Design, New Age International (P) Ltd., Publishers, 2009
7. K Das, M. Das. An Introduction to Supramolecular Chemistry, CBS PUBLICATION, 2017

	MAHATMA GANDHI UNIVERSITY
	CSM21E44 Theory of Polymer Solutions

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Theory of Polymer Solutions**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E44**					
Course Summary & Justification	The course outlines the fundamentals of polymer solubility, solubility parameters, thermodynamics and theories of polymer solutions etc. The course also focuses on the configuration and conformation of macromolecules. This course aims to introduce the fundamental concepts that describe the concept of solubility and solubility parameters. The solubility parameter is very much important in selecting the material for processing. The thermodynamics of polymer solutions helps to identify the miscibility and compatibility of different types of polymers and their blends					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge about chemistry at the bachelor's level					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To understand the basics of solubility and solubility of different types of materials	U	1, 2
2	To understand the thermodynamics of polymer solutions	U, An	2, 3
3	To understand the significance of different theories of polymer solutions	U, An	4-7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Introduction Content for classroom transaction (Sub-units) 1.1. Solubility of low molecular weight substances and polymers, theories of polymer solubility-different stages of polymer solubility, fractional precipitation, non-solvents, solubility of amorphous and crystalline polymers, solubility parameter concept	10	1
Unit 2: Thermodynamics of polymer solution Content for classroom transaction (Sub-units) 2.1. Lattice theory and its advantages and limitations, Flory-Huggins and Flory-Kingbaum theories and their advantages and limitations, corresponding state theories, Flory temperature, polymer-solvent interaction parameter, the unperturbed polymer chain, expansibility factor, entropy, enthalpy and free energy of mixing of polymer solution 2.2. Phase separation in polymer systems, De Gennes and Edwards tube models, self-avoiding random walk, scaling concepts in polymer systems, pearl model	15	2
Unit 3: Configuration and confirmation of macromolecules Content for classroom transaction (Sub-units) 3.1. Pseudochirality, stereoregular polymers, tacticity, monotactic and ditactic polymers, geometrical isomerism, experimental methods for the determination of configuration, conformation of the single polymer molecule. 3.2. Free rotation, rotation about single bonds, average chain dimensions, freely jointed chains, random flight model, derivation of end-to-end distance, real polymer chains, bond angle restrictions, steric restriction 3.3. Conformation in crystals, micro conformation in solution, ideal coil molecules in solution, Compact molecules, optically active polyolefins, polyaminoacids, proteins, conformational transitions.	15	2, 3

Teaching and Learning Approach	**Classroom Procedure: Learning Approach Consists of** Direct Instruction: Brain storming Lecture, Explicit Teaching, E-learning Interactive Instruction, Seminar, Group Assignments, Flipping, Progressive tests, Blended learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test • Seminar Presentation in a related topic and review a journal paper in a particular area and present before peers **B. Semester End examination**

REFERENCES

SUGGESTED READINGS

1. P. J. Flory, Principles of Polymer Chemistry, Cornel University Press, 1953.
2. H. G. Elias, Macromolecules: Structure and Properties, Springer, 1977.
3. A. Tager, Physical Chemistry of Polymer, 2nd Edn. Mir Publishers, 1978.
4. F. W. Billmeyer, Text Book of Polymer Science, 3rd Edn., Wiley, 1984.
5. I. Teraoka, Polymer Solutions: An Introduction to Physical Properties, Wiley-Inter-science, 2002.
6. M. G. Cowie, V. Arrighi, Polymers: Chemistry and Physics of Modern Materials, 3rd Edn. CRC Press, 2008.
7. F. A. Bovey, Polymer Configuration and Conformation, Academic press, 1969

	MAHATMA GANDHI UNIVERSITY
	CSM21E46 Main Group Elements Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Main Group Elements Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E46**					
Course Summary & Justification	Main group elements, the most abundant elements in the universe were among the first developed in the modern era for diverse inter-disciplinary applications. Learning this elective course will provide a strong foundation in the key concepts of Main Group Elements, which will help the students to develop a holistic view of elemental composition and material design in science and technology. Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences. This course is structured to introduce students to the descriptive chemistry of the main group elements and its wide range of applications. The learners will be able to apply, analyse and evaluate the structure and bonding aspects of inorganic and organometallic compounds derived from main group elements.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge about periodic table and arrangements of elements under Groups and Periods					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the classification of elements in the periodic table: general trends and properties of elements and structure of molecules	U	1
2	Understand Acid-Base theory concepts and apply these principles to evaluate various chemical reactions	U	3

3	Build a perspective on the origin, occurrence and extraction of group I and group II elements and their different compounds.	U	2
4	Understand the Chemistry of group III elements and apply Wade's rule and STYX number in rationalizing the structure of main group clusters	U, A	6, 7
5	Understand the diversity of oxides, sulfides, halides and hydrides of group IV, V and VI elements	U	2, 3, 7
6	Understand the preparation and properties of Halogens, Noble gas compounds, Cyclic ethers, Crown ethers and Clathrates.	U	4, 6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Classification of elements in the periodic table Content for Classroom Transaction (Sub-units) 1.1. General trends in the properties of the elements 1.2. Anomalous behaviour of the first member of the group elements 1.3. Diborane, Wades', Isolobal principle, molecular geometry and molecular symmetry 1.4. Electronic configuration of the di and tri atomic systems 1.5. Bond types, bond properties, electron-deficient, precise and rich compounds	6	1
Unit 2: Acids and Bases		
Content for Classroom Transaction (Sub-units) 2.1. Theories of acids and bases, Bronsted Acidity and characteristics of Bronsted acids, Lewis acidity 2.2. Hard and Soft acids and bases, HSAB Principle 2.3. Applications of acid-base chemistry (Super acids and bases)	4	2
Unit 3: Group I and Group II elements Content for Classroom Transaction (Sub-units) 3.1. Occurrence and extraction; Group I and II elements and their compounds: hydrides, halides, oxides, hydroxides, sulphides, selenides, tellurides and related compounds 3.2. Compounds of Oxo- acids, Nitrides and Carbides 3.3. Solubility and Hydration 3.4. Solutions in liquid ammonia 3.5. Alkali and alkaline earth metals and its complexes 3.6. Grignard reagents	6	3
Unit 4: Chemistry of group III elements: Inorganic chains, rings and cages Content for Classroom Transaction (Sub-units) 4.1. Boranes, Boron halides, Diborane, Borazines, Borates, Boron clusters, Higher boranes and borohydrides 4.2. Organoboranes: carboranes and metallocarboranes 4.3. STYX numbers and WADE's rule 4.4. Isolobal concept: molecular geometry and molecular symmetry 4.5. Main group clusters: Cyclic and crown ethers	9	4

Unit 5: Oxides of group IV elements Content for Classroom Transaction (Sub-units) 5.1. Silicon-oxygen compounds, Silicates, Silicons, Zeolites, Silanes, Silylamines and extended Silicon- Oxygen compounds 5.2. Carbides and Silicides 5.3. Complexes of Ge, Sn and Pb 5.4. Diamond, graphite and other forms of carbon	5	5
Unit 6: General structure and characteristics of group V and VI elements Content for Classroom Transaction (Sub-units) 6.1. Hydrides of group V and VI elements 6.2. Phosphanes, phosphorous halides and phosphazenes 6.3. Oxohalides and Oxoacids of P, S, Se and Te	5	5
Unit 7: Halogens and Noble gases Content for Classroom Transaction (Sub-units) 7.1. Oxoacids of halogens, Interhalogen compounds and polihalides 7.2. Chemistry of noble gases, Compounds of Xenon (structure and reactivity) 7.3. Clatharates	5	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction): Learning Approach Consists of** Direct Instruction: Brain storming Lecture, Explicit Teaching, E-learning Interactive Instruction, Active co-operative learning, Seminar, Group Assignments, Progressive tests, Blended learning, Quizzes, Presentation by individual student/ Group representatives, and flipping.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test • Seminar Presentation on a related topic and review a journal paper in a particular area and present before peers. **B. Semester End examination**

REFERENCES

SUGGESTED READINGS

1. W. Henderson, Main Group Chemistry, Royal Society of Chemistry, 2000.
2. F. A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th Edn. John Wiley and Sons, 2007.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn. Pearson Education, 2000.
4. M. Weller, T. Overton, J. Rourke, F. Amstrong, Inorganic Chemistry, 6th Edn. Oxford University Press, 2015
5. N. N. Greenwood, A. Earnshaw, Chemistry of the Elements, Pergamon Press, 1984.
6. K. F. Purcel, J. L. Kotz, An Introduction to Inorganic Chemistry, Saunders College, 1980.

	MAHATMA GANDHI UNIVERSITY
	CSM21E51 Bioinorganic Chemistry

SchoolName	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Bioinorganic Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E51**					
Course Summary & Justification	This course provides the students a detailed knowledge of fundamental aspects of bioinorganic chemistry. The students will understand the role of metal ions and inorganic complexes in biological processes. They will learn about metal toxicity as well as the application of inorganic complexes as therapeutics. This course will give a strong foundation to research metalloenzyme applications, inorganic biomaterials and pharmaceutical development.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge of Inorganic Chemistry and Biology					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Apply the basic principles in inorganic and general chemistry to bioinorganic chemistry.	A	1
2	Understand the importance of metals in biological systems.	U	3
3	Remember the structure and functions of metalloproteins and metalloenzymes	R	1
4	Explain the role of metal ions that are involved in electron transfer reactions in biological systems.	R	1
5	Identify the metal centers involved in oxygen transport in living organisms and comprehend the mechanism of this process.	U	1
6	Understand the biological role of Iron, copper, zinc and molybdenum	U	3, 7
7	Know the medical applications of bioinorganic compounds	U	3, 7

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT	Hours	CO No
Unit 1: Bioinorganic Chemistry of Alkali and Alkaline Earth Metals Content for Classroom Transaction (Sub-units) 1.1. Essential elements in biological systems 1.2. Transport of ions across biological membranes 1.3. Na^+/K^+ pump 1.4. Transport and structural role of calcium	3	1, 2
Unit 2: Bioinorganic Chemistry of Iron Content for Classroom Transaction (Sub-units) 2.1. Myoglobin 2.2. Hemoglobin 2.3. Cytochromes, Cytochrome P-450, Cytochrome c oxidase 2.4. Transport and storage of Iron: Ferritin, Transferrin, Siderophores 2.5. Catalase and peroxidase 2.6. Non-heme protein: Hemerythrin and Fe-S clusters 2.7. Model compounds of these proteins/enzymes	10	3-6
Unit 3: Bioinorganic Chemistry of Copper, Zinc and Molybdenum Content for Classroom Transaction (Sub-units) 3.1. Type I, II and III Copper proteins 3.2. Zn-containing enzymes 3.3. Zn-finger proteins 3.4. Alcohol dehydrogenase 3.5. Xanthine oxidase 3.6. Aldehyde Oxidase 3.7. Model compounds of these proteins/enzymes	9	3-6
Unit 4: Nitrogen fixation, Photosynthesis andVitamin B_{12} Content for Classroom Transaction (Sub-units) 4.1. Nitrogen fixation and nitrogenase enzyme 4.2. Photosynthesis 4.3. Vitamin B_{12} and B_{12} coenzymes 4.4. Model compounds of these proteins/enzymes	4	3, 4, 6
Unit 5: Metal ions and diseases Content for Classroom Transaction (Sub-units) 5.1. Role of Mn, Ni, Mo and Cr in biology 5.2. Metallothioneins 5.3. Metal toxicity 5.4. Thalassaemia, Wilson disease and Sickle-cell anemia	3	6
Unit 6: Effect of hazardous materials on the human body Content for Classroom Transaction (Sub-units) 6.1. Generation and function of organic free radicals 6.2. Action of reactive oxygen species (ROS) in biological systems 6.3. Nitric oxide 6.4. Cyanide and CO poisoning	3	5, 6

Unit 7: Medicinal bioinorganic chemistry Content for Classroom Transaction (Sub-units) 7.1. Metal ion-based (Pt, V, Au) drugs 7.2. Chelation therapy 7.3. Macrocyclic antibiotics 7.4. Photodynamic therapy 7.5. MRI imaging and contrast agents	4	7
Unit 8: Biomimetics and Supramolecular Chemistry Content for Classroom Transaction (Sub-units) 8.1. Biomimetic compounds 8.2. Picket-fence porphyrin 8.3. Crown ethers 8.4. Cryptands and cryptates 8.5. Calixarenes and cyclo-dextrins	4	1, 7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar/ Presentation by individual students, Assignments, Library work, Authentic learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – MCQ-based and descriptive answer type • Seminar Presentation – the students will be given individual topics for the seminar presentation • Assignments • Quizzes **B. Semester End examination**

REFERENCES

1. J. E. Huheey, R. A. Keiter, R. L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn. Prentice Hall, 1997.
2. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th Edn. Wiley-Interscience, 1999.
3. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver and Atkins Inorganic Chemistry. 4th Edn. Oxford University Press, 2006.
4. J. D. Atwood, Inorganic and Organometallic Reaction Mechanism 2nd Edn. Wiley-VCH, 1997
5. E. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn. Wiley-India, 2007.
6. W. Kaim, B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, John Wiley & Sons, 1994

	MAHATMA GANDHI UNIVERSITY
	CSM21E52 Chemical Bonding and Group Theory

SchoolName	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Chemical Bonding and Group Theory**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E52**					
Course Summary & Justification	Learning the principles behind chemical bonding and the basics of group theory along with the applications. This course helps in familiarising the symmetry elements and symmetry operations and also identification of point groups associated with a molecule. It also helps to determine the molecular orbitals and hybridisation of molecules.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Eg. Authentic learning, Collaborative learning, Independent learning, etc.	40	0	0	60	100
Pre-requisite	Basic knowledge of Quantum Mechanics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	An insight into chemical bonding	U	1, 3
2	An insight into group theory	U	1, 2, 4, 5
3	Understand bonding in diatomic molecules	A	1, 6, 7
4	Identify point groups of the molecules	A	1, 3, 5
5	Determining the molecular orbitals of molecules using group theory	A	4, 5
6	Deriving hybridization of molecules using group theory	A	4-7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

COURSE CONTENT	Hours	CO No
Unit 1: Approximate methods in Quantum Chemistry Content for Classroom Transaction (Sub-units) 1.1. Variation and perturbation methods 1.2. Linear variation method	10	1
Unit 2: Diatomic Molecules and Chemical bonding Content for Classroom Transaction (Sub-units) 2.1. Born-Oppenheimer approximation 2.2. Valence bond and Molecular Orbital theory 2.3. Hydrogen molecule ion and hydrogen molecule 2.4. Molecular Orbitals of homonuclear diatomic molecules	12	1, 3
Unit 3: The simple Huckel Method and applications Content for Classroom Transaction (Sub-units) 3.1. The assumption of σ-π separability 3.2. Independent π-electron assumption 3.3. Setting up the Huckel secular determinant 3.4. Solving the HMO determinantal equation for orbital energies 3.5. Solving for the molecular orbitals 3.6. Degenerate systems-cyclopropenyl system 3.7. Charge distributions from HMO theory 3.8. Simplifying generalizations 3.9. Simple Applications	12	1
Unit 4: Group Theory in Chemistry Content for Classroom Transaction (Sub-units) 4.1. Symmetry elements and symmetry operations 4.2. Symmetry point groups 4.3. Definition of group 4.4. Group multiplication table 4.5. Abelian and degenerate groups. 4.6. Cyclic groups 4.7. Subgroups 4.8. Representation of groups 4.9. Generating representations from basis functions 4.10. Reducible and irreducible representations	13	2, 4
Unit 5: Connection between Group theory and Quantum Mechanics Content for Classroom Transaction(Sub-units) 5.1. Orthogonality in irreducible inequivalent representations 5.2. Characters and character tables 5.3. Resolving a reducible representation 5.4. Identifying Molecular Orbital symmetries 5.5. Generating symmetry orbitals 5.6. Hybrid orbitals and localized orbitals 5.7. Symmetry and integration	13	5, 6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments Seminar, Authentic learning, Library work, independent studies Presentation by individual student

Assessment Types	Mode of Assessment
	A. Continuous Internal Assessment (CIA) • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

REFERENCES

1. J. P. Lowe, Quantum Chemistry, 2nd Edn. Acdemic Press, 1993.
2. F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn. Wiley-Interscience, 1990.
3. P. W. Atkins, R. S. Friedman, Molecular Quantum Mechanics, 3rd Edn. Oxford University Press, 1999.
4. N. Levine, Quantum Chemistry, 5th Edn. Prentice Hall, 1999.
5. S. C. Rakshit, Molecular Symmetry Groups and Chemistry, Current Distributors, 1985.

	MAHATMA GANDHI UNIVERSITY
	CSM21E55 Biochemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Biochemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E55**					
Course Summary & Justification	The course Biochemistry is designed for the study of the molecular composition of living cells, the organization of biological molecules within the cell, and the structure and function of these biological molecules. The biological macromolecules that this course focuses on are proteins, polysaccharides, and polynucleic acids (DNA and RNA), including the monomeric units of these macromolecules. The structures of these molecules, their functions, and the strong relationship between structure and function and the metabolism of these biomolecules are also included. We will also examine the structure and function of lipids, a fourth important type of biological molecule and a major component of cell membranes. Along with the study of lipids, we will examine biological transport in membranes. Other topics to be taught in the course include the energetics of biological processes and the kinetics and catalytic mechanisms of enzymes.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge of organic chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the structure-function relationship of biomolecules, and their importance with regard to maintenance and perpetuation of the living systems.	U	1
2	Be familiar with the enzymes (biocatalysts), and their salient attributes including unique conformation and amazing catalytic properties.	A	3

3	Analyze the various types of weak interactions between the biomolecules	Ap	1, 6
4	Correlate how biomolecules such as proteins, carbohydrates, lipids, nucleic acids are formed from the simple precursors and their role in different metabolic pathways	An	1, 2, 6
5	Interpret the structure-function relationships of the proteins, carbohydrates, lipids, and nucleic acids.	E	2, 7
6	Relate the structure of DNA with its function in Replication and gene expression that includes both transcription and translation.	U	3, 7
7	Understand the difference between the water-soluble and fat-soluble vitamins and their key role in the metabolism as coenzymes.	E	7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: INTRODUCTION TO BIOMOLECULES Content for Classroom Transaction (Sub-units) 1.1. Structure and functions of biomolecules-water as a biological solvent 1.2. Amino Acids, peptides and Proteins: Introduction, Classification optical isomerism, chemical properties, acid-base properties- Peptide bond formation and properties. Levels of protein structure (brief mention of primary, secondary, tertiary & quaternary structures), Denaturation of proteins- Ramachandran plot- Determination of Primary Structure - sequencing strategies N-terminal and C-terminal sequencing. Chemical synthesis of peptides- Merrifield Solid phase synthesis enzymes: Introduction, classification of enzymes, mechanism of enzyme action, enzyme kinetics, Enzyme kinetics, Michaelis – Menten equation and graphical evaluation of K_M and V_{max}. 1.3. Carbohydrates: Structure of monosaccharides- Aldoses and ketoses- Stereo-isomerism of sugars; Ring structures and anomeric forms, mutarotation, Structure, occurrence and biological importance of monosaccharides, oligosaccharides and polysaccharides namely glycogen, starch, cellulose, chitin, agar, pectins, proteoglycans. Fischer projections, Haworth structures, pyranose and furanose structures, Anomers, Epimers, Chair and boat conformations, R and S configuration. Structure and functions of sugars, homo and heteropolysaccharides, glycoconjugates, glycoproteins 1.4. Nucleic acids: Purine and pyrimidine bases, Nucleotides and nucleic acids, Composition of DNA and RNA, structural features of nucleic acids, DNA double helix, Watson and Crick model denaturation and annealing of DNA; Structures and roles of different types of RNA; Replication of DNA, Gene expression, Protein Biosynthesis, DNA Repair, Recombinant DNA techniques	12	1-7

Unit 2: Fatty acids and Lipids Content for Classroom Transaction (Sub-units) 2.1. Classification of lipids; oils, fats, and waxes 2.2. Occurrence and properties of fatty acids, esters of fatty acids, Phosopholipids, glycolipids, sphingolipids, cerebrosides and gangliosides 2.3. Structure of membranes 2.4. Transport across membranes active and passive transports	8	1, 3, 4, 5, 7
Unit 3: Vitamins Content for Classroom Transaction (Sub-units) 3.1. Classification-water soluble vitamins and fat-soluble vitamins 3.2. Vitamins as co-factors in enzyme catalysis	4	1, 7
Unit 4: Bioenergetics and metabolism Content for Classroom Transaction (Sub-units) 4.1. Biochemical thermodynamics, the energy changes accompanying biochemical reactions 4.2. Overview and selected individual and important oxidative pathways. 4.3. Glycolysis, TCA cycle-pentose phosphate pathway. 4.4. Citric acid cycle: energetic and amphibolic nature. 4.5. Regulatory aspects of TCA cycle and glycolysis. 4.6. Photosynthetic electron transport and phosphorylation and CO_2 fixation. 4.7. Oxidative phosphorylation and electron transport	8	1, 4, 7
Unit 5: Transfer of genetic information Content for Classroom Transaction (Sub-units) 5.1. Chemistry of nucleic acids, nucleotide, nucleoside, cyclic AMP. 5.2. Assembly of DNA, types of RNA. 5.3. Replication of DNA: enzymology in eucaryotes and bacteria, translation, genetic code, protein biosynthesis. 5.4. Regulation of gene expression. Repair of DNA and recombinant DNA concept	8	1, 3, 6, 7

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments Seminar, Authentic learning, Library work, independent studies Presentation by individual student
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

References

1. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 6th Edn. 2014
2. J. M. Berg, J. L. Tymoczko, L. Stryer, Biochemistry, 6th Edn. 2006
3. R. H. Garret, C. M. Grisham, Biochemistry, Brooks/Cole, 6th Edn. 2016
4. G. L. Zubay, Biochemistry, Wm. C. Brown Publishers, 1998

	MAHATMA GANDHI UNIVERSITY
	CSM21E56 Natural and Synthetic Polymers

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Natural and Synthetic Polymers**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E56**					
Course Summary & Justification	Natural and Synthetic Polymers course is designed to provide a comprehensive understanding of all the important types of natural and synthetic polymers and related topics. This will enable the learners to acquire sufficient knowledge and awareness about different classes of polymer substances. A constructive discussion based on a broad classification of polymeric materials as thermoplastic, thermosetting resins, rubber, fiber forming materials, etc are also included. The syllabus mainly covers the synthesis, properties and applications of important polymeric materials including natural, synthetic, and semi-synthetic polymers. After completion of this course, students are expected to have a detailed understanding of important natural and synthetic polymeric materials and to acquire sufficient knowledge and ability to identify and differentiate between them in terms of their properties and applications.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include Group discussions, Seminars, Independent Learning, etc.	40	0	0	60	100
Pre-requisite	Basic awareness of various types of polymers.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	To familiarize with various types polymers	R, U	1, 2, 6, 7
2	To Acquire sound knowledge about the fundamentals and importance of various Natural and synthetic polymers	U, I	1, 6, 7
3	To classify the polymers based on structure, functionality and properties.	U, An	2, 6, 7
4	*To understand the peculiarities of individual polymer materials and compare each other*	U, A, E	1, 6, 7

5	To Evaluate and correlate various polymer properties for specified applications	A, An, E, C	1, 2, 5, 6, 7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Introduction Comparison between Natural and synthetic polymers. Polymer as plastics, rubbers and fibres. A detailed account of the Synthesis, properties and applications of the following Industrial polymer	4	1-5
Unit 2: Polyolefins/Vinyl polymers LDPE, LLDPE, HDPE, UHMWPE, chlorinated and chloro-sulphonated polyethylenes, polypropylene. PVC, PVA, PVAc	7	
Unit 3: Acrylic polymers PMMA, polyacrylonitrile, polyacrylic acid, cyanoacrylates.	4	
Unit 4: Styrenic polymers Polystyrene, high impact polystyrenes-rubber modified polystyrenes, SAN, ABS, foamed polystyrene-thermocole.	6	
Unit 5: Fluorocarbon polymers PTFE, PCTFE, PVF, PVDF etc.	4	
Unit 6: Thermoplastic condensation polymers Polyesters-PET, PBT, Poly amides-nylons, acrylics, fiber forming polymers	5	
Unit 7: Thermosets Unsaturated polyesters-epoxy resins, PF, UF and MF. various prepolymer products, curing agents for these resins.	5	
Unit 8: Biopolymers Carbohydrates, Starch, cellulose, cellulose derived semisynthetic polymers, Poly amino acids, Proteins, Natural rubber etc.	9	

Teaching and Learning Approach	**Classroom Procedure (mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (40%)** • Internal Tests, • Assignments • Seminar Presentation • Review Report **B. End Semester Examination (60%)**

References

1. J. A. Brydson, Plastic Materials, Butterworth-Heinemann, 7th Edn. 1998

Suggested Readings

2. F. W. Billmeyer, Text Book of Polymer Science, Wiley interscience, 1976.

3. J. M. G. Cowie, Polymers: Chemistry & Physics of Materials, International Text Book Company Ltd, 1974.
4. D. Feldman, A. Barbalata, Synthetic Polymers, Springer, 1996.
5. R. W. Hyson, specialty polymers, Chapmann and Hall, 1987
6. A. H. Frazer, High Temperature Resistant Polymers. Wiley interscience,1963
7. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn. Butterworth Scientific, 1982
8. H. F. Mark, Encyclopaedia of polymer science and engineering, Vol 9, Wiley intersciences, 1987

	MAHATMA GANDHI UNIVERSITY
	CSM21E57 Medicinal Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Medicinal Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E57**					
Course Summary & Justification	Medicinal Chemistry has grown as an important and distinct branch of Organic Chemistry over several decades. The importance of medicinal chemistry is growing day by day due to the emergence of new diseases caused by microorganisms, changes in lifestyle of human beings, pollution, etc. This warrants a good understanding of medicinal chemistry for the new generation of chemists. This course is designed to provide students with a comprehensive understanding of various aspects of modern medicinal chemistry and its applications. In this course, in addition to learning the basics of medicinal chemistry, students will be equipped with designing new scaffolds for drug synthesis Understanding this subject will enable the students to work in frontier areas of multidisciplinary sciences.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Understanding of basic organic reactions, basic stereochemistry, and reaction mechanism					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Acquires the ability to understand the basics of medicinal chemistry	U	1
2	Equip the student with sufficient skill to understand the different stages in drug discovery enabling to work in discovery research.	U	2, 3
3	Acquires the basics of cancer research and enable to work in cancer research.	A	1, 2, 3, 6
4	Acquires the basics of antibiotics.	U	1

5	Acquires the basics of antiviral and antifungal diseases and enables to work in drug research.	A	1, 2, 6
6	Acquires the basics of analgesics and anti-inflammatory drugs. Provide students with the skills required to perform in R & D drug research.	S	1, 2, 6
7	Acquires the basics of Hyperacidity and related diseases Provide students with the skills required to perform in R & D drug research.	S	1, 2, 6
8	Acquires the basics of cardiovascular diseases. Provide students with the skills required to perform in R & D drug research.	S	1, 2, 6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Basics of medicinal chemistry 1.1. A brief history of drugs 1.2. Development of medicinal chemistry 1.3. Basic principles 1.4. Basic terminology in drug Discovery 1.5. IC50 1.6. Log P 1.7. Log D 1.8. MIC 1.9. Efficacy 1.10. Adsorption 1.11. Distribution 1.12. Metabolism 1.13. Excretion 1.14. Drug and disease classification 1.15. Drug targets 1.16. Pharmacology 1.17. Pharmacokinetics 1.18. Generic and trade names 1.19. Lipinski rule 1.20. Dose-response curves	8	1
Unit 2: Stages in drug discovery 2.1. SAR and QSAR 2.2. Natural and synthetic drugs 2.3. Introduction to process research	4	2
Unit 3: Cancer research 3.1. Cancer and anti-cancer agents 3.2. Aromatase inhibitors for cancer treatment	6	3
Unit 4: Antibiotics 4.1. Antibacterials (Cipro and Zyvox) 4.2. β-lactam antibiotics (Penicillins) 4.3. Tetracyclines and Quinolones (Fluoroquinolones) 4.4. Basic knowledge of TB and its treatment	6	4

Unit 5: Antiviral and Antifungal agentes 5.1. Antiviral drugs (Tamiflu) 5.2. Antifungal drugs (Fluconazole)	6	5
Unit 6: Analgesics and Anti-inflammatory drugs 6.1. Analgesics (Cimetidine) 6.2. Opioid analgesics Morphine 6.3. Anti-inflammatory drugs (Celebrex)-NSAIDS (Ibuprofen, Naproxen)	6	6, 7
Unit 7: Proton pump inhibitors 7.1. Hyperacidity 7.2. Peptic Ulcer disease (PUD) 7.3. ATPase inhibitors-Omeprazole and Esomeprazole (Nexium) 7.4. Gastroesophageal reflux disease (GERD)	6	7
Unit 8: Cardiovascular diseases 8.1. Hypertension 8.2. Cardiovascular drugs-Statin drugs 8.3. ACE inhibitors 8.4. Calcium channel inhibitors 8.5. Cholesterol absorption inhibitors	8	8

Teaching and Learning Approach	**Classroom Procedure: Learning Approach Consists of** Direct Instruction: Brainstorming lecture, Explicit Teaching, E-learning, interactive Instruction, Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – One MCQ based and on extended answer type • Book review – every student to review a seminal work on Alternative Education and submit a report • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar • Field visit report – each student shall individually or in a group visit an institution with demonstrated experience of alternative thoughts and prepare a report **B. Semester End examination**

REFERENCES

1. G. L. Patrick, An introduction to Medicinal Chemistry, Oxford University Press, 1995
2. G. Thomas, Fundamentals of Medicinal Chemistry, Wiley, 2003

SUGGESTED READINGS

1. W. Sneader, Drug Discovery, A History, John Wiley, England, 2005
2. X-T Liang, W-S Fang, Medicinal Chemistry of Bioactive Natural Products, Wiley, 2006
3. A. Kar, Medicinal Chemistry, New age international publishers, New Delhi, 2005
4. R. S. Vardanyan, V. J. Hruby, Synthesis of Essential Drugs, Elsevier, 2006

5. C. G. Wermuth, The Practice of Medicinal Chemistry, Academic Press, Oxford, 2003.

	MAHATMA GANDHI UNIVERSITY
	CSM21E58 Chemistry of Heterocyclic Compounds

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Chemistry of Heterocyclic Compounds**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E58**					
Course Summary & Justification	The study of the chemistry of heterocyclic compounds introduces the basic idea of heterocyclic chemistry. Through this learning, it is possible to acquire relevant knowledge about various heterocyclic compounds, their preparation and properties. The syllabus also discusses the conformational studies of those compounds. Understanding this subject will enable the students to work in frontier areas of heterocyclics**.**					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge about chemistry at the Bachelors level					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Gain a theoretical understanding of the fundamentals of Heterocyclic compounds	U	1, 6, 7
2	Classify and write the nomenclature of various heterocyclic molecules	U, An	2, 3
3	Explain the reactivity and other properties of heterocyclic compounds.	U, An	4, 5
4	Develop synthetic strategies for heterocyclic compounds.	An, E	1, 3, 5
5	Application of heterocycles in drug synthesis.	Ap	5, 6, 7
6	Gain an idea of the conformational analysis of heterocyclic compounds	U, An	3, 4
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Heterocyclic compounds 1.1. Introduction and nomenclature of heterocycles- monocyclic, fused and bridged systems. 1.2. Classification of heterocycles based on structure-General properties of heterocycles- Three and four-membered heterocycles: azirine, oxirane, azetidine, oxetene, oxetane and thietane: properties and synthesis.	10	1, 2, 3, 6
Unit 2: Five-Membered Heterocyclic compounds 2.1. Five membered heterocyclic systems: pyrrole, furan, thiophene. 2.2. Five membered heterocycles with two or more hetero atom spyrazole and imidazole, isoxazole, thiazole and triazole-properties and synthesis. 2.3. Benzofused systems- indole, indolizine, carbazole benzofuran, dibenzofurans	8	1-6
Unit 3: Six and Seven Membered Heterocyclic compounds 3.1. Heterocyclic analogs of six and seven-membered rings and fused systems: 3.2. Synthesis and reactions of pyridine, pyran, quinoline, isoquinoline, acridine and phenanthridine. 2- and 4- pyrones, benzopyran, and benzopyrones, azepine, thiepine, diazepine. 3.3. Synthesis and chemical properties. Compounds with two or more than two hetero atoms; pyridazine, pyrimidine, pyrazine, oxazine, thiazine, dioxane, quinazoline, quinaxaline, cinnoline, pteridine, triazenes.	10	1-6
Unit 4: Non- aromatic Heterocycles 4.1. Non-aromatic heterocycles - Aziridines, Thiiranes, oxiranes, oxetane, azetidine, THF, pyrrolidone, piperidine, tetrahydropyran - preparation and their applications	6	2, 3, 6
Unit 5: Conformational analysis of heterocyclic compounds 5.1. Strain - bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of 6-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction.	6	1, 2, 6

Teaching and Learning Approach	**Classroom Procedure: Learning Approach Consists of** Direct Instruction: Brain storming Lecture, Explicit Teaching, E-learning, Interactive Instruction, Seminar, Group Assignments, Flipping, Progressive tests, Blended learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test • Seminar Presentation in a related topic and review a journal paper in a particular area and present before peers **B. Semester End examination**

REFERENCES

SUGGESTED READINGS

1. R. M. Acheson, An introduction to the chemistry of Heterocyclic compounds, Wiley India Pvt. Ltd. 3rd Edn. 2008
2. T. Eicher, S. Hauptmann, The Chemistry of Heterocycles.
3. J. A. Joule, K. Mills, G. F. Smith, Heterocyclic Chemistry.
4. T. L. Gilchrist, Heterocyclic Chemistry.
5. T. Eicher, S. Hauptmann, A. Speicher, The Chemistry of Heterocycles: Structures, Reactions, Synthesis, and Applications 3rd Edn. 1999.
6. L. D. Quin, J. A. Tyrell, Fundamentals of Heterocyclic Chemistry: Importance in Nature and the Synthesis of Pharmaceuticals, 2010.

	MAHATMA GANDHI UNIVERSITY
	CSM21E59 Chemistry of Coordination Compounds

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Chemistry of Coordination Compounds**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E59**					
Course Summary & Justification	The course aims to help the students detail the bonding, structures and properties of coordination complexes. The description of various bonding theories with emphasize on the spectral and magnetic properties of coordination complexes helps to predict the characteristic properties of any transition metal complex. Different reactions in transition metal complexes with a supportive mechanism will be discussed. The applications of coordination chemistry in various fields will also be described in the conclusion part to understand the importance of learning this course.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge of Inorganic Chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To understand the structure and bonding of coordination complex	U	1
2	To write down the IUPAC name of the complexes	A	1, 2
3	To predict the shape of coordination complexes using VBT & CFT	A	1, 2
4	To identify the types of isomers in coordination compounds	A	1, 2
5	To use ligand field theory to understand the spectral and magnetic properties	U	1, 2, 3
6	To estimate the CFSE of any complex and predicts low spin/high spin nature	E	1, 2, 3
7	Should be able to derive the term symbol for any electronic configuration	E	1, 2, 3
8	Should be able to draw Orgel diagrams and recognise the electronic transition in the spectra of any coordination complexes	E	1, 2, 3

9	To be able to describe the stability of coordination complexes by the use of formation constants and to calculate thermodynamic parameters from them.	An	1, 2, 3
10	To predict the products formed after electron transfer reaction between two coordination complexes.	An	1, 2, 3
11	To familiarized with some applications of coordination compounds in daily life	U	5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Theories of Bonding in Coordination Compounds Content for Classroom Transaction (Sub-units) 1.1. Valence Bond theory 1.2. Crystal Field Theory 1.2.2. Splitting of d orbitals in different fields 1.2.3. Crystal field splitting and crystal field stabilization energy 1.2.4. Spectrochemical series 1.2.5. Jahn Teller distortion 1.2.6. Nephelauxetic effect 1.2.7. Two-dimensional spectrochemical series 1.2 Ligand Field Theory 1.3. Molecular Orbital theory-MO energy level diagram for octahedral complexes without and with π-bonding	10	1-6
Unit 2: Electronic Spectra of Complexes Content for Classroom Transaction (Sub-units) 2.1. Term symbols 2.2. d-d transition and charge transfer transition 2.3. Selection rules for electronic transition 2.4. Effect of spin-orbit coupling and vibronic coupling on electronic transition 2.5. Orgel diagrams 2.6. Applications of electronic spectra in the structural studies of complexes	12	7, 8
Unit 3: Magnetic Spectra of Metal Complexes Content for Classroom Transaction (Sub-units) 3.1. Thermal population of different energy levels-large and small multiplet widths 3.2. Spin-only magnetic moment 3.3. Orbital contribution to magnetic moment 3.4. Antiferromagnetism 3.5. Applications of magnetic data in the structural studies of complexes	10	9
Unit 4: Kinetics and Reaction Mechanism of Coordination compounds Content for Classroom Transaction (Sub-units) 4.1. Lability and inertness 4.2. Ligand displacement reactions in octahedral and square complexes 4.3. Trans effect theories and applications 4.4. Electron transfer reactions-outer sphere and inner sphere processes	15	10, 11

Unit 5: Applications of metal complexes Content for Classroom Transaction (Sub-units) 5.1. Applications of coordination compounds in analytical chemistry	3	11

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Lecture (Chalk and Blackboard teaching), Explicit Teaching, E-learning (Google classroom) **Interactive Instruction**: Active co-operative learning, PowerPoint Presentation by student, Assignments, Library work, Authentic learning, Quizzes
Assessment Types	**Mode of Assessment** **1. Continuous Internal Assessment (CIA)** • Internal Test – MCQ-based and descriptive answer type • Seminar Presentation – the students will be given individual topics for seminar presentation • Assignments • Quizzes **2. Semester End examination**

REFERENCES

1. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 3rd Edn. Wiley, 1972.
2. J. E. Huheey, R. A. Keiter, R. L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn. Prentice Hall, 1997.
3. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn. John Wiley & Sons, 2006.
4. J. D. Lee, Concise Inorganic Chemistry, 5th Edn. Chapman & Hall1996.
5. A. Earnshaw, Introduction to Magnetochemistry, Academic Press, 1968.

	MAHATMA GANDHI UNIVERSITY
	CSM21E71 Fundamentals of Electrochemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Fundamentals of Electrochemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E71**					
Course Summary & Justification	Electrochemistry: Topics to be covered include: ion activity, ionic equilibria and acid-base theory, electrolytic conduction, reversible (equilibrium) potentials, applications of electrode potentials and cell e.m.fs, interfacial phenomena, electrode processes, exploitation of electrode processes. To impart knowledge in advanced electrochemistry to analyze electrode kinetics, explain various over potential involved during the operation of the cell, to apply the knowledge to calculate electrochemical cell parameters, over potential, electrochemical cells as sources of energy and in electrocatalysis and electro organic synthesis					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40		0	60	100
Pre-requisite	Bachelors degree in chemistry, with physics and mathematics as subsidiaries.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	After completion of the course, the learner can be able to understand: Basic principles of laws of electrochemistry, electrodes, EMF measurement, potentiometric/conductometric titrations and their applications.	U	1
2	The learner should be able to apply theories in electrochemistry to analyze electrode kinetics, explain various over potential involved during the operation the cell, to apply the knowledge to calculate electrochemical cell parameters, and over potential.	A	6, 7
3	To impart knowledge of advanced electrochemistry.	Ap	2

4	The students will acquire knowledge of potentiometric, coulometric, and voltametric methods of analysis.	A	4
5	Build a perspective on the applications of electrochemistry in daily life like pH, buffers, colloids, etc.	U	6, 7

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT	Hours	CO No
Unit 1: Ion Activity 1.1. Content for Classroom Transaction (Sub-units) 1.2. Ion-ion and ion-solvent interaction 1.3. The electrical potential in the vicinity of an ion 1.4. Electrical potential and thermodynamic functions - the Debye-Huckel equation, limiting and extended forms of Debye-Huckel equation, applications of Debye-Huckel equation 1.5. Ion association	5	1
Unit 2: Ionic Equilibria and Acid-base Theory 2.1. Classical theory, Bronsted-Lowry concept of acids and bases 2.2. Strengths of acids and bases in aqueous solution 2.3. Hydrolysis, the extent of acidity - the pH scale, buffer systems 2.4. Acid-base indicators 2.5. General acid-base theory and non-aqueous solvents.	5	1, 4
Unit 3: Electrolytic Conduction 3.1. Significance of conductivity data 3.2. Conductivity and transport properties of ions 3.3. Relationships between molar conductivity and concentration 3.4. Conductivity at high field strengths and high frequency of alternation of the field 3.5. Electrical migration and transport numbers 3.6. Applications of conductivity measurements.	5	1, 5
Unit 4: Reversible (equilibrium) Potentials 4.1. Comparison of chemical and electrochemical reactions 4.2. Reversible electrode potentials 4.3. The hydrogen scale, other reference electrodes, electrochemical concentration cells 4.4. Concentration cells without liquid junctions, concentration cells with liquid junctions.	5	2, 5
Unit 5: Applications of Electrode Potentials and Cell e.m.fs 5.1. Thermodynamics of cell reactions 5.2. Determination of standard potentials and mean ion activity coefficients 5.3. Transport number determinations 5.4. Determination of equilibrium constants 5.5. The determination of pH, other electrochemical detectors, and potentiometry.	5	2, 5

Unit 6: Interfacial Phenomena 6.1. Significance of the interface between conduction phases, the electrode double layer 6.2. Polarized and non-polarized electrodes, the diffuse double layer, electrocapillarity 6.3. Electrokinetic phenomena 6.4. The behaviour of colloidal systems, and membrane equilibria.	5	1, 4
Unit 7: Electrode Processes 7.1. Non-equilibrium electrode potentials, electrode kinetics, Nernst equation 7.2. Dependence of current density on overvoltage – the Tafel equation 7.3. electrolysis and overvoltage, hydrogen and oxygen overvoltage theories of hydrogen overvoltage.	5	2, 5
Unit 8: Exploitation of Electrode Processes 8.1. Polarography and voltammetry, mixed potentials and double electrodes 8.2. Corrosion: concept and importance, mechanism of corrosion and pourbaix diagrams 8.3. Electrochemical processes as sources of energy, fuel cells 8.4. Electrocatalysis and electrosynthesis.	5	3, 5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brain storming lecture, Explicit Teaching, E-learning, **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – On MCQ based and on extended answer type • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar **B. End semester examination**

REFERENCES

1. R. Crow, Principles and Applications of Electrochemistry, 3rd Edn. Chapman and Hall, 1988.

SUGGESTED READINGS

1. S. Glasstone, An Introduction to Electrochemistry, Maurice Press, 2008
2. J. O. M. Bockris, A. K. N. Reddy, Modern Electrochemistry Vol. I & II, Springer, 1988.
3. V. S. Bagotsky, Fundamentals of Electrochemistry, 2nd Edn. Wiley & Sons, 2005
4. S. Iqbal, Textbook of Electrochemistry, Discovery Publishing House Pvt. Ltd. 1993

	MAHATMA GANDHI UNIVERSITY
	CSM21E72 Computational Methods in Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Computational Methods in Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E72**					
Course Summary & Justification	Chemistry is traditionally an experimental science dealing with the structure, functions and reactivity of molecules and the methods for making them from convenient starting materials. With the advent of quantum mechanics, a better understanding of atomic and molecular structure was initiated but significant progress was delayed because of the difficulties in calculating all the necessary multicenter integrals and the necessity of diagonalizing large matrices. With the arrival of faster and even faster computers, these calculations are becoming possible and getting more accurate. A study of large molecular clusters and liquids was also initiated using interaction potentials and classical equations of motion. Now these methods are extended to surfaces, multiple phases and topics covering various aspects of molecular biology. In the present course, we shall investigate many aspects that touch upon the issues related to the above problems.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	20	0	60	120
Pre-requisite	Basic knowledge of C programming and Numerical methods					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	An insight into C programming	U	1
2	An insight into Numerical methods	U	1
3	An insight to non-numerical algorithms	A	1
4	Determining the values of Taylor series expansions	A	1

5	Understanding of Stochastic programming	A	1, 2
6	Understand basic concepts of Computational Chemistry	U	1, 3, 6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Mathematical preliminaries Content for Classroom Transaction (Sub-units) 1.1. Elementary combinatorics 1.2. Stirling's approximation 1.3. Method of Lagrange multipliers 1.4. Introduction to probability 1.5. Gamma functions 1.6. Power series method	5	2, 4
Unit 2: Physics preliminaries Content for Classroom Transaction (Sub-units) 2.1. Classical mechanics 2.1.1. Newtonian, Lagrangian and Hamiltonian approach to mechanics 2.2. Quantum Mechanics 2.2.1. Hydrogen atom, rigid rotor and harmonic oscillator	3	1, 2
Unit 3: Classical and quantum statistics Content for Classroom Transaction (Sub-units) 3.1. Bose-Einstein statistics 3.2. Fermi Dirac statistics 3.3. Maxwell Boltzmann statistics	3	3
Unit 4: Ensemble theory Content for Classroom Transaction (Sub-units) 4.1. Gibb's hypothesis 4.2. Concept of phase space 4.3. Postulate of equal apriori probabilities 4.4. Ensemble averages 4.5. Partition function	4	3, 5
Unit 5: Canonical ensemble Content for Classroom Transaction (Sub-units) 5.1. Evaluation of undetermined Lagrange multipliers 5.2. Boltzmann's hypothesis	3	3, 5
Unit 6: Other ensembles Content for Classroom Transaction (Sub-units) 6.1. Micro canonical ensemble 6.2. Grand canonical ensemble	2	3, 5

Unit 7: Ideal gas Content for Classroom Transaction (Sub-units) 7.1. Derivation of PV= nRT from first principles 7.2. Expressions for heat capacity at constant volume and constant pressure.	3	3, 5
Unit 8: Molecular interactions in liquids Content for Classroom Transaction (Sub-units) 8.1. Radial distribution function g(r) 8.2. Calculation of g(r) using Monte Carlo method 8.3. Calculation of g(r) using molecular dynamics approach	4	3, 5
Unit 9: Chemical equilibrium Content for Classroom Transaction (Sub-units) 9.1. Connection between the equilibrium constant of gas phase reactions and the canonical partition function	3	3, 5
Unit 10: Solids Content for Classroom Transaction (Sub-units) 10.1. Einstein and Debye theory of solids. 10.2. Phonons	5	6
Unit 11: Metals and Photons Content for Classroom Transaction (Sub-units) 11.1. Fermi function and Fermi energy. 11.2. Free electron model and density of states. 11.3. An ideal gas of photons (black body radiation)	5	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments Seminar, Authentic learning, Library work, independent studies Presentation by individual students, Computational lab
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar • Performance in Lab **B. Semester End examination**

REFERENCES

1. W. Kernigan, D. M Ritchie, The C programming Language, 2nd Edn. Prentice Hall, 1988.
2. E. Kreyszig, Advanced Engineering Mathematics, 10th Edn., John Wiley and sons, 2011
3. F. Jensen, Introduction to Computational Chemistry, 2nd Edn. Wiley, 2007.
4. E. G. Lewars, Computational Chemistry, Introduction to Theory and Application of Molecular and Quantum Mechanics, Springer, 2004.

	MAHATMA GANDHI UNIVERSITY
	CSM21E74 Surface Chemistry and Catalysis

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Surface Chemistry and Catalysis**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E74**					
Course Summary & Justification	Introduce the main techniques of surface science and understand how these techniques can be used to investigate the structure, composition, and reactivity of surfaces with a particular focus on systems of relevance to heterogeneous catalysis. To introduce the important general concepts of the chemistry of heterogeneous catalysis and to describe and illustrate the main types.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	00	0	60	100
Pre-requisite	Bachelors degree in chemistry, with physics and mathematics as subsidiaries.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To introduce the concepts of adsorption and desorption	U	1
2	To explain many of the proposed hypotheses of surfaces in terms of fundamental concepts.	A	3
3	Be able to apply the knowledge to predict and rationalize the properties of catalysts.	Ap	1, 2
4	To understand the role of a catalyst in relation to thermodynamics and to appreciate the relevance of catalyst activity, selectivity, deactivation and regeneration.	A	1
5	Recognize assumptions and limitations in the scientific models and their possible impact on the results by training on case studies, lectures, assignments, quizzes	U	1, 2
6	Having a clear understanding of the subject-related concepts and contemporary issues.	U	4

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT	Hours	CO No
Unit 1: Adsorption at Liquid Surfaces 1.1. Adsorption at liquid surfaces 1.2. Gibb's equation and its verification, adsorption forces 1.3. Thermodynamics of physical adsorption, Heat of adsorption and its determination.	8	1
Unit 2: Adsorption on Solids 2.1. Adsorption on solids, Langmuir adsorption isotherm, Multilayer adsorption, BET and Polanyi models for the adsorption. 2.2. Electrical phenomena at interfaces including electrokinetic potentials 2.3. Micelles, Critical Micelle Concentration (CMC). 2.4. Relevance of surfaces and interfaces: colloids, nanomaterials & biology	8	2
Unit 3: Characterization of Solid Surfaces 3.1. Harkins and Jura equation and other methods for measurements of the surface area of solids 3.2. Diffraction and thermal methods - Powder X-Ray diffraction- peak broadening and particle size analysis, N_2 adsorption -surface area, pore size analysis, thermal analysis using TGA and DTA 3.3. Morphology and particle size analysis - SEM, AFM and HR-TEM	8	3
Unit 4: Adsorption Behaviour of Porous Materials 4.1. Porous solids, Pore size distribution 4.2. Adsorption behaviour of porous materials, hysteresis of adsorption 4.3. Theory of surface reactions 4.4. Molecular sieves, Capillary condensation, micro-pore analysis.	8	4, 5
Unit 5: Catalysis 5.1. Homogeneous catalysis, Autocatalysis and oscillating reaction, 5.2. Kinetics of homogeneous catalysis 5.3. Heterogeneous catalysis 5.4. Kinetics of heterogeneous catalysis 5.5. Development of catalysts 5.6. Enzyme catalysis.	8	1, 2, 5, 6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** **Direct Instruction**: Brain storming lecture, Explicit Teaching, E-learning, **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test – On MCQ based and on extended answer type • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar **B. End semester examination**

REFERENCES

1. P. W. Atkins, Julio de Paula, Atkins' Physical Chemistry, Oxford University Press, 9th Edn. Reprinted, 2011.
2. P. Bolgar, H. Lloyd, A. North, V. Oleinikovas, S. Smith, J. Keeler, P. Atkins' Physical Chemistry, 11th Edn. Oxford University Press, 2017.
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SUGGESTED READINGS

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	MAHATMA GANDHI UNIVERSITY
	CSM21E76 Chemistry of Natural Products

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Chemistry of Natural Products**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E76**					
Course Summary & Justification	This course provides an introduction to the broad field of Natural Products Chemistry by reviewing the major classes of Natural Products. The students will study the isolation, classification, identification and synthesis of natural products.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge of organic chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Provide an overview of the field of natural product chemistry	U	1
2	Identify the different classes of natural products	An	2
3	Explain the different methods used for the isolation and purification of natural products	A	2
4	Discuss the various degradation techniques employed in the structure elucidation of natural products	R	6
5	Outline the synthesis of typical compounds belonging to different classes of natural products	Ap	7
6	Understand the pharmacological effects of natural products and their applications in the field of medicinal and drug chemistry.	U	4
7	Design alternate routes for the synthesis of some terpenes and alkaloids	C	6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: ALKALOIDS Content for Classroom Transaction (Sub-units) 1.1. General introduction to natural products. 1.2. Methods for the isolation and purification of natural products 1.3. Alkaloids- classification, 1.4. Isolation and purification 1.5. Methods for the structure elucidation of alkaloids 1.6. Synthesis of atropine, quinine, reserpine and morphine	10	1-7
Unit 2: TERPENES Content for Classroom Transaction (Sub-units) 2.1. Terpenoids- general properties and classification 2.2. Methods for the isolation and purification of terpenoids 2.3. Structure elucidation and synthesis of citral, α-pinene, camphor, carotenoids and longifolene. Structure of taxol, synthesis. 2.4. Biosynthesis of terpenes	10	1-7
Unit 3: LIPIDS Content for Classroom Transaction (Sub-units) 3.1. Fatty acids and triglycerides- occurrence, and isolation 3.2. Classification 3.3. Membrane lipids 3.4. Soaps and micelles 3.5. Biosynthesis of lipids	7	1 ,2, 3
Unit 4: STEROIDS Content for Classroom Transaction (Sub-units) 4.1. Steroids- Nomenclature, stereochemistry 4.2. Physical methods of characterization and properties 4.3. Cholesterol, ergo sterol, vitamin D, progesterone, testosterone and cortisone 4.4. Biosynthesis of cholesterol	5	1, 2, 3
Unit 5: FLAVANOIDS Content for Classroom Transaction (Sub-units) 5.1. structure and properties of Flavonoids and Isoflavanoids 5.2. Tests for Flavanoids 5.3. Isolation and Purification of Flavanoids	3	1, 2, 3
Unit 6: Prostaglandins **Content for Classroom Transaction (Sub-units)** 6.1. Prostaglandins – Structure, classification and biological functions 6.2. Types of Prostaglandins, nomenclature, biosynthetic pathway, Prostaglandins E2 and F2.	3	1, 2, 3, 6

Unit 7: Pheromones Introduction, examples, and importance in IPM synthesis of juvabione, bombycol, grandisol and disparlure. Content for Classroom Transaction (Sub-units) 7.1. Structure and Biological Functions 7.2. Types of Pheromones	2	2, 3, 6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments Seminar, Authentic learning, Library work, independent studies Presentation by individual student
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

REFERENCES

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	MAHATMA GANDHI UNIVERSITY
	CSM21E77 Nanomaterials

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Nanomaterials**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E77**					
Course Summary & Justification	Nano-science and technology is the study of materials of small dimensions that possess remarkable properties to address the challenging problems faced by science and society. This elective course, ***Nanomaterials*** provides the fundamental understanding of nanomaterials that will create and use structures, devices and systems at nanoscale level. It also includes various fabrication and characterization methods for nanomaterials. In the upcoming section, surface properties of nanoscale materials are included, which connects nanostructures with surface energy. This course will expose students to broad areas like nano-optics, nanotechnological materials and devices that are designed to provide industrial and commercial applications.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge about chemistry at the Bachelor's level.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understanding the fundamentals of nanomaterials and familiarises with various synthesis approaches for nanomaterial synthesis.	U	1
2	Describe various types of nanomaterials, nanocrystals, nanoparticles, low dimensional solids like fullerenes, nanotubes and nanowires.	U	3
3	Understand different techniques for nanomaterials characterization and apply these tools to evaluate the properties of nanomaterials.	U, A	6, 7
4	Gain insight into the surface properties of nanomaterials with special emphasis on spherical cluster approximation, packing fraction and structural magic numbers.	U, An	5

5	Build a perspective on nano-optics, Surface Plasmon Resonance (SPR), colour generation from nanoparticles and quantum dots.	U	4
6	Describe microporous and mesoporous materials from soft building blocks that have applications in Hydrogen storage systems, coordination frameworks, and crystalline organic frameworks.	U	2
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Unit 1: Introduction to Nanoscience 1.1. Defining nano-dimensional materials, size effects in nanomaterials. 1.2. Synthesis of nanomaterials: physical and chemical methods of synthesis, Nano fabrication methods: top-down and bottom-up methods, self-assembly, quantum concepts.	8	1
Unit 2: Types of Nanostructured materials 2.1. Nanocrystals, nanoparticles, oxide nanostructures 2.2. Low-dimensional solids: fullerenes, nanotubes, nanowires and nanomaterials.	5	2
Unit 3: Characterization methods of Nanoparticles 3.1. Electron probe methods: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) 3.2. Scanning probe microscopy methods: Atomic force microscopy (AFM). 3.3. Spectroscopic methods: UV-Visible Absorption Spectroscopy, X-ray diffraction analysis. 3.4. Non-radiative & non-destruction characterization methods: Determination of particle size, surface area and porosity- BET method, BJH method, Mercury Porosimeter method.	7	3
Unit 4: Materials, Structure and the Nano-surface 4.1. Particle shape and the surface: Exterior surface and particle shape, interior nanoscale surface area. 4.2. Surface and Volume: Specific surface area, Spherical cluster approximation 4.3. Atomic Structure: Packing fraction and density, Structural magic numbers.	7	4
Unit 5: Nano-optics 5.1. Introduction to nano-optics; Interaction of light with nanoparticles. 5.2. The Surface Plasmon Resonance (SPR), colour generation from nanoparticles. 5.3. Quantum dots.	7	5
Unit 6: Microporous and mesoporous materials from soft building blocks 6.1. Zeolite, modular self-assembly of microporous materials. 6.2. Hydrogen storage, coordination frameworks, crystalline organic frameworks.	6	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Direct Instruction, Brain storming lectures, Explicit Teaching, E-learning, Interactive Instruction, Active Co-operative Learning, Seminars, Group Assignments, Authentic Learning, Library Work and Group Discussion, Presentation by individual student/ Group representatives, Progressive tests, Blended Learning, Quizzes and Flipping.
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test • Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar **B. Semester End examination**

REFERENCES

1. H. S. Nalwa, R. Smalley, Encyclopaedia of Nanoscience and Technology, American Scientific Pub. 2004.
2. N. R. Rao, A. Govindraj, Nanotubes and Nanowires, 2nd Edn. RSC, 2011.
3. J. E. Huheey, R. A. Keiter, R. L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, Prentice Hall, 1997.
4. N. R. Rao, A. Muller, A. K. Cheetham, The Chemistry of Nanomaterials, Vol 1 &2, John Wiley & Sons, 2005.
5. G. Schmid, Nanoparticles: From Theory to Applications, John Wiley & Sons, 2011.
6. G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.
7. G. A. Ozin, A. C. Arsenault, L. Cademartiri, Nanochemistry- A Chemical Approach to Nanomaterials, RSC Publishing, 2009.

	MAHATMA GANDHI UNIVERSITY
	CSM21E82 Industrial Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Industrial Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E82**					
Course Summary & Justification	Through this course, the students will learn how to apply chemistry for the transformation of materials and energy to manufacture the products which are used in our daily life. The environmental issues caused by industrial pollution, effective waste management techniques and the use of green chemistry as an alternative methodology are discussed in detail. This course bridge the gap between classical chemistry and the chemistry applied in the industries.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	-	0	60	100
Pre-requisite	Basic knowledge in Chemistry at the Undergraduate level					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Describe the fundamental aspects of chemical industry.	U	1
2	Know the various purification techniques used in chemical industries.	U	1
3	Gain sound knowledge of the industrial production of some important organic and inorganic compounds or chemicals.	U, An	1, 3, 7
4	Learn the properties and applications of industrial polymers.	U	1, 3, 7
5	Evaluate environmental issues related to the chemical industry and waste management.	E	1
6	Understand the basic concept and applications of green chemistry.	U, An	1, 3
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	Hours	CO No
Unit 1: Introduction to Industrial Chemistry Content for Classroom Transaction (Sub-units) 1.1. Unit operations and unit processes 1.2. Flow diagrams 1.3. Fuels and calorific value 1.4. Safety measures 1.5. ISO certification 1.6. Material and energy balances	3	1
Unit 2: Chemistry in Industrial Processes Content for Classroom Transaction (Sub-units) 2.1. Distillation 2.2. Liquid-Liquid Extraction 2.3. Filtration 2.4. Equipment for heat exchange 2.5. Crystallization 2.6. Absorption and adsorption	5	2
Unit 3: Industrially important inorganic materials Content for Classroom Transaction (Sub-units) 3.1. Cement 3.2. Glass 3.3. Ceramics 3.4. Inorganic Fertilizers 3.5. Refractory materials – carbides and borides, zeolites 3.6. Molecular sieves 3.7. NASICON	6	3
Unit 4: Organic Chemical Industries Content for Classroom Transaction (Sub-units) 4.1. Petroleum and Petrochemicals 4.2. Fermentation 4.3. Ethanol 4.4. Pharmaceuticals 4.5. Oils, Soaps and detergents	5	3
Unit 5: Industrial Polymers Content for Classroom Transaction (Sub-units) 5.1. Polymer liquid crystals 5.2. Polyolefins 5.3. polyvinyl carbazides 5.4. poly acrylics 5.5. PMMA 5.6. poly methacrylics	6	4

Unit 6: Industrially important materials Content for Classroom Transaction (Sub-units) 6.1. Paints 6.2. Dyes 6.3. Pigments 6.4. Pharmaceutical products 6.5. Food Chemistry 6.6. High Energy Materials	5	3
Unit 7: Industrial Waste Management Content for Classroom Transaction (Sub-units) 7.1. Definition 7.2. Types of Industrial wastes 7.3. Management of wastes 7.4. Reuse and recycling 7.5. Waste treatment 7.6. Waste utilization and materials recovery	5	5
Unit 8: Green Chemistry Content for Classroom Transaction (Sub-units) 8.1. Introduction and need of green chemistry 8.2. Principles of green chemistry 8.3. Tools of green chemistry 8.4. Examples of green chemistry	5	6

Teaching and Learning Approach	**Classroom Procedure** **Learning Approach Consists of** Direct Instruction: Brain storming Lecture, Explicit Teaching, E-learning Interactive Instruction, Seminar, Group Assignments, Flipping, Progressive tests, Blended learning, Quizzes
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** • Internal Test • Seminar Presentation in a related topic and review a journal paper in a particular area and present before peers **B. Semester End examination**

- Polymer chain flexibility as the basic determinant,
- Structural factors influencing chain flexibility: secondary bond forces, configuration, crystallinity, texture (linearity, branching and crosslinking), pendant groups, ring structure in chain backbone, presence of condensed ring systems and variation in molecular weight.
- Effect of chain flexibility on thermal, rheological and mechanical properties.
- Structural parameters determining optical and electrical properties.
- Theory of random coil, estimation of coil dimensions

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13. P. T. Anastas, J. C. Warner, Green Chemistry: Theory and Practice, Oxford Univ. Press. Oxford, 1998.
14. P. T. Anastas, T. C. Williamson, Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes, Oxford Univ. Press. Oxford, 1999.

	MAHATMA GANDHI UNIVERSITY
	CSM21E91 Review Report

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Review Report**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E91**					
Course Summary & Justification	The candidate has to do a review on a topic of current research interest under the guidance of a Supervising Teacher of the School of Chemical Sciences and submit the corresponding report at the end of the fourth semester.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Literature survey, independent learning					
Pre-requisite						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course, the students are expected to		
1	Carry out literature survey-Familiarise with journal abstracting, inculcate a scientific temper and research interest, and make understand and be aware of recent trends in the topic chosen. Journal reading and writing skill.	A	2, 3, 4, 5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Deeper knowledge of methods in the major subject of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6
7	Create, analyse and critically evaluate different problems and their solutions.	C	2, 3, 6, 7
8	Gain a consciousness of the ethical aspects of research.	E	7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction, Seminar, Authentic learning, Library work, laboratory work, Teamwork, independent learning and Group discussion, Presentation of research work
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners

	MAHATMA GANDHI UNIVERSITY
	CSM21E92 Industry Visit Report

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Industry Visit Report**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E92**					
Course Summary & Justification	The students have to visit an industry in the presence of a faculty member of the School of Chemical Sciences during the programme and submit a report on the same at the end of the fourth semester.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Visiting the industry and interacting with the personnel	-	-	-	-	-
Pre-requisite	Basic knowledge in chemistry practicals and industrial chemistry					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course, the students are expected to		
1	Demonstrate the applications of chemical concepts and principles learned in the classroom.	A	1, 2, 3
2	Illustrate processes and products manufactured in the chemical industries.	A	2, 4
3	Develop awareness of the principles and technological aspects of the chemical industries.	C	2
4	Improve interpersonal skills by communicating directly with industrial personnel.	S	5
5	Aware of the impacts of industrial processes on health, safety, environment and society.	E	6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	Main aim of industrial visit is to provide an exposure to students about practical working environment. They also provide students a good opportunity to gain full awareness about industrial practices. Through industrial visit students get awareness about new technologies.

Assessment Types	Mode of Assessment
	The report shall be evaluated by the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner.

	MAHATMA GANDHI UNIVERSITY
	CSM21E94 Instrumental Methods in Organic Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Instrumental Methods in Organic Chemistry**					
Course Credit	**2**					
Type of Course	**ELECTIVE**					
Course Code	**CSM21E94**					
Course Summary & Justification	The study of Instrumental Methods in Organic Chemistry introduces the basic as well as advanced concepts and applications of instrumental methods of organic chemistry. Through this learning, it is possible to acquire relevant conceptual and procedural knowledge, and to develop an understanding and appreciation of developments in various analytical fields. This course will provide a strong foundation in the key concepts to advanced fields like 3D NMR, Solid-state NMR, Augur spectroscopy, and so on. Understanding of this subject will enable the students to work in frontier areas of multidisciplinary sciences.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	40	0	0	60	100
Pre-requisite	Basic knowledge about chemistry at the Bachelors level					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the fundamentals of various types of chromatographic techniques	U	1
2	Get an idea about the application and instrumentation of Optical Rotatory Dispersion and Circular Dichroism	U, An	2, 3
3	Understand the different mass spectrometric methods at in advanced level	U, An	2, 3
4	Understand the basic concepts of INDOR and NDMR spectroscopy	U	6, 7

5	Acquire knowledge about the modern techniques used in organic chemistry	A, An	6, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT	**Hours**	**CO No**
Content for Classroom Transaction (Sub-units) **Unit 1: Spectroscopic Methods** 1.1. Principles, Instrumentation, and Applications of the following Spectroscopic Techniques 1.1.1. Infra-red (IR) Spectroscopy 1.1.2. UV-Visible Spectroscopy 1.1.3. Raman Spectroscopy 1.1.4. Photoluminescence (PL) Spectroscopy 1.1.5. Fluorescence Spectroscopy 1.2. Basic principles of Chromatography-History, Classification, Principle & basic theory of chromatography	10	2, 3, 4
Unit 2: Thermal Methods of Analysis and Electron Microscopic Techniques 2.1. Principle, Instrumentation and Applications of the following Thermal Analysis Techniques 2.1.1. Thermogravimetric analysis (TGA), 2.1.2. Differential thermal analysis (DTA), 2.1.3. Differential Scanning Calorimmetry (DSC) 2.1.4. Thermomechanical Analysis (TMA) 2.1.5. Dynamic Mechanical Analysis (DMA) 2.1.6. Applications of DTA, DSC, TGA, TMA and DMA in characterization of materials 2.2. Principle, Instrumentation, and Applications of the following Electron Microscopic Techniques 2.2.1. Scanning Electron Microscopy (SEM) 2.2.2. Transmission Electron Microscopy (TEM) 2.2.3. Atomic Force Microscope (AFM)	8	5

Unit 3: Chromatographic Techniques: Types of chromatography 3.1. Liquid Chromatography: Introduction, Column adsorption chromatography, Partition chromatography, Band broadening & column efficiency, Factors affecting, Plate theory & Rate theory of chromatography, Types of Liquid chromatography. 3.2. Theory, principle and Instrumentation of HPLC, Types of columns, Column efficiency, Pumps, Various types of detectors, Injection system, Isocratic and gradient elution, Normal phase and Reverse phase liquid chromatography, Development of HPLC and UPLC method, Choice of stationary and mobile phase, Difference between HPLC and UPLC, Applications. 3.3. Gas Chromatography Introduction, Types of Gas chromatography, Theory principle and Instrumentation of gas chromatography, Carrier gas, Injection port, Types columns, Solid inert support, Stationary phase, Mobile phase, Role of Detectors, Thermal conductivity detector, Flame Ionization detector, Flame photometric detector, Development of GC method, Column silanization, Factor affecting to separation, Temperature programming, Application. 3.4. Thin Layer Chromatography Introduction, Theory, Principle and Instrumentation of TLC, Method for the preparation of thin layers on plates, Application of sample on the chromoplates, Choice of adsorbent, Choice of mobile phase, Detecting reagent, Developing chamber, Developing and detection, Ascending, Descending and two dimensional TLC development, Impurity profiling with the help of TLC, Applications 3.5. Paper Chromatography and Hyphenated techniques Paper Chromatography - Introduction, Types of PC, Theory, principle and technique of PC, Types of paper, Modification of the paper, Choice of solvents, Rf value measurement, Sample application, Precautions in PC, Quantitative estimation by PC, Applications. Hyphenated techniques - GC-MS, HP-TLC, LC-MS, etc. Principle & Application 3.6. Flash Chromatography -Theory and applications 3.7. Flow Chemistry Equipment	10	1
Unit 4: Optical Rotatory Dispersion and Circular Dichroism Spectroscopy 4.1. Theory and applications of ORD and CD, Cotton Effect, Octant Rule 4.2. Faraday and Kerr effects 4.3. Instruments for measuring ORD and CD	5	2
Unit 5: Other commonly used Instruments 5.1. Microwave Synthesis Equipment 5.2. Rotary Evaporators 5.3. Temperature Control Equipment 5.4. Ultrasonic Devices	7	5

Teaching and Learning Approach	**Classroom Procedure: Learning Approach Consists of** Direct Instruction: Brain storming Lecture, Explicit Teaching, E-learning Interactive Instruction, Seminar, Group Assignments, Flipping, Progressive tests, Blended learning, Quizzes

Assessment Types	Mode of Assessment **A. Continuous Internal Assessment (CIA)** • Internal test • Assignment • Seminar presentation in a related topic **B. Semester End examination**

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3. E. L. Eliel, Stereochemistry of Carbon Compounds, McGraw Hill Education, 2001.

	MAHATMA GANDHI UNIVERSITY
	CSM21O86 Environmental Chemistry

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Environmental Chemistry**					
Course Credit	**4**					
Type of Course	**OPEN COURSE**					
Course Code	**CSM21O86**					
Course Summary& Justification	This course aims to apply chemical principles to the study of the environment. This course includes the natural chemical processes and environmental issues such as global warming, air, water, and soil pollution. This course addresses various techniques used to analyse the quality of air, water and soil and describes effective waste management methods. Learning this course is essential to understand and develop possible methods to reduce pollution and thereby attain environmental protection and sustainability.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include Group discussions, Seminars, Independent Learning, etc.	40	40	0	40	120
Pre-requisite	Nil					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Gain knowledge of the natural cycles of the environment	U	1
2	Understand how human activities affect environment and analyse its consequences	U, An	1
3	Describe the causes of air, soil and water pollution and appreciate suitable waste management techniques	U, Ap	1
4	Evaluate various methods to determine the quality of air, water and soil.	An, E	2, 3
5	Understand the instrumental techniques used to analyse environment.	U, An	2, 3
6	Develop mitigation strategies for reducing environmental pollution	E, C	3, 5, 7

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT	Hours	CO No
Unit 1: Environment Content for Classroom Transaction (Sub-units) 1.1. Global warming 1.2. Ozone hole 1.3. Environmental segments 1.4. Hydrological cycle 1.5. Oxygen cycle 1.6. Nitrogen cycle 1.7. Sulphur cycle 1.8. Composition of atmosphere 1.9. Earth's radiation balance 1.10. Greenhouse effect	20	1-6
Unit 2: Air pollution Content for Classroom Transaction (Sub-units) 2.1. Primary pollutants 2.2. Acid rain 2.3. Air quality standards 2.4. Sampling, Monitoring and Analysis of CO, nitrogen oxides, sulphur oxides, hydrocarbons and particulate matter 2.5. Control of air pollution	15	3, 4
Unit 3: Soil pollution Content for Classroom Transaction (Sub-units) 3.1. Inorganic and organic components in soil 3.2. Acid-Base and ion exchange reactions in soils 3.3. Micro and macronutrients 3.4. Wastes and pollutants in soil	15	3, 4
Unit 4: Water pollution Content for Classroom Transaction (Sub-units) 4.1. Water pollutants 4.2. Eutrophication 4.3. Water quality criteria for domestic and industrial uses 4.4. Trace elements in water 4.5. Determination of quality parameters 4.5.1. Total hardness 4.5.2. TDS 4.5.3. pH 4.5.4. Chloride 4.5.5. Heavy metals 4.6. Principles of water and wastewater treatment 4.6.1. Aerobic treatment 4.6.2. Anaerobic treatment 4.7. Industrial wastewater treatment 4.8. Removal of organic and inorganic materials from water and waste water.	15	3, 4

Unit 5: Instrumental techniques in environmental analysis Content for Classroom Transaction (Sub-units) 5.1. Neutron activation analysis 5.2. ASV 5.3. AAS 5.4. GC 5.5. HPLC 5.6. Ion selective electrodes 5.7. Ion chromatography in environmental chemical analysis	15	5, 6

Teaching and Learning Approach	**Classroom Procedure (mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (40%)** • Internal Tests, Assignments, Seminar Presentation, Review Report **B. End Semester Examination (60%)**

References

1. G. W. VanLoon, S. J. Duffy, Environmental Chemistry, Oxford University Press, 2005
2. J. Girard, Principles of Environmental Chemistry, Jones & Bartlett Learning, 2005.
3. S. E. Manahan, Environmental Chemistry, Seventh Edition, CRC Press, 2010
4. E. R. Weiner, Applications of Environmental Chemistry, CRC Press, 2010.
5. I. I. Williams, Environmental Chemistry, John Wiley, 2001.
6. G. Schwedt, The essential guide to environmental chemistry, John Wiley, 2001.

	MAHATMA GANDHI UNIVERSITY
	CSM21O87 Science and Society

School Name	**School of Chemical Sciences**					
Programme	**M.Sc.**					
Course Name	**Science and Society**					
Course Credit	**4**					
Type of Course	**OPEN COURSE**					
Course Code	**CSM21O87**					
Course Summary& Justification	This open course is designed as a multidisciplinary course that aims to provide a critical understanding for learners of the significance of science in society and vice-versa. The syllabus covers the history of science, developments of sciences, and approaches in science. The syllabus also deals with various processes and approaches adopted in scientific research. Finally, consciousness about scientific ethics is also discussed. This course further offers the prospects for understanding the contemporary trends and growth in diverse fields of scientific research. After completion of this course, students will be able to correlate the mutual relationship and significance between science and society.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include Group discussions, Seminars, Independent Learning, etc.	40	40	0	40	120
Pre-requisite	Nil					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	To acquire a concrete understanding of the importance of scientific knowledge and its implications in society	U, An, I, Ap	3, 5
2	To provide sufficient knowledge about the history of major scientific discoveries and developments	R, U, E, Ap	3, 5
3	*To understand the peculiarities of scientific approaches*	U, A	3, 5
4	To Correlate the relationship between scientific and social developments in mankind	An, E, I	3,5
5	To outline the basic steps in scientific research	U, A	3,5
6	To develop critical thinking and reasoning ability among learners	A, An, E, S	1,3,5

7	To impart scientific ethics among learners	U, A	2, 3
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

	Hours	CO No
Unit 1: The Scientific Approach	8	1-7
Process of science and the nature of scientific knowledge. Science as a creative human activity. The evolution of modern Science and Technology. Ideas in science: Research Process, hypotheses, theories and laws. The process of science beyond methods: science as an art, creativity in science, scientific controversy.		
Unit 2: The History of Science	10	
Ancient civilisation in India, China, Babylon, Egypt, Greece, Rome, Aristotelian views, Archimedes, The Copernican revolution, Contributions of Galileo, Louis Pasteur, Newton, Einstein, Linus Pauling, Developments and Revolutions in various branches of science, Science in twenty-first century		
Unit 3: Teaching critical thinking	10	
Improving reasoning, Critical thinking, Affective strategies, Cognitive strategies, Media role, Science and knowledge, Beliefs, Justification		
Unit 4: The Practice of science	30	
Research methods-comparison, description, experimentation, and modelling. Identification of a problem, determination of the mode of attack, literature survey, mode of approach of actual investigation, abstraction of the research paper, drawing influences from data, qualitative and quantitative analysis, internet and its applications, e-journals, assessing the status of the problem, results and conclusions, presenting a scientific seminar, publication of research paper, art of writing a thesis.		
Unit 5: Scientific ethics	8	3, 7
Verifiability and reproducibility, Plagiarism, IPR, Cyber laws, Internet security		

Teaching and Learning Approach	**Classroom Procedure (mode of transaction)** **Direct Instruction**: Lecture, Explicit Teaching, E-learning **Interactive Instruction**: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (40%)** • Internal Tests, Assignments, Seminar Presentation, Review Report **B. End Semester Examination (60%)**

Main References

1. J. S. Avery, Science and Society, World scientific Publishing Company.

Suggested Reading

1. J. D. Bernal, Science in history, 1-4 Volumes, MIT Press, Cambridge,1971.
2. W. Durant, The Story of Civilization, Simon and Schuster Publishers, United States, 1975
3. B. Russell, The Scientific Outlook, Routledge Classics, United Kingdom, 2009
4. K. Sujatha, S. Kurien, Evolution of the Philosophy of Science-Literary Perspectives, Ane Books Pvt. Ltd, 2011.
5. G. Gammow, One, two, three…infinity, Dover Publications, INC, NewYork, 1974
6. T. Crump, A Brief History of Science, Universities Press, 2001.
7. B. N. Ghosh, Lectures on Scientific Method, Sterling, 1986.

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Implementation Date	