GOVERNMENT ARTS COLLEGE (AUTONOMOUS)

COIMBATORE-641 018

Learning outcomes-based Curriculum Framework (LOCF) for

M.Sc. CHEMISTRY

(Effective from Academic year 2021-2022)

POSTGRADUATE AND RESEARCH

DEPARTMENT OF CHEMISTRY

MAY-2021

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Preamble

Over the past decades higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects learning outcome based curriculum in order to maximize the benefits of the newly designed curriculum. The learning outcome based curriculum in general and in Chemistry in particular will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this.

Tamil Nadu State Council for Higher Education (TANSCHE) has formed the State Integrated Boards of Studies, which, with great diligence and expertise has devised the mandatory areas that have to be covered for three year under-graduation and two year post-graduation courses to realize the facilitation of the mobility of faculty and students from one university to another and to easily solve the problem of equivalence among courses. Great care has been taken so that these areas would take 75% of the course content and the remaining 25% can be decided by the individual institutions. The areas that must be covered by the student that are mandatory for earning the degree to have due value has been worked out so that the student will gain enough depth of knowledge in the subject concerned. 25% percent of the syllabus should be designed by the institutions, and the areas covered under this also must have a weightage of 25%. This gives the autonomous institution seamless liberty on every Board of Studies (BOS) to innovate and experiment, and more importantly, it is here that the institution devises appropriate strategies by which (i) to make creative and critical applications of what has been learnt in the mandatory components, and (ii) to meaningfully connect the learners to the career demands and expectations. It is essential that the theoretical subject knowledge of the students must be translated into practical hands-on experience.

One of the significant reforms in the undergraduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. LOCF also aims at ensuring uniform education standard and content delivery across the country which will help the students to ensure similar quality of education irrespective of the institute and location. With initiatives of University Grants Commission (UGC) for nation-wide adoption and

implementation of the LOCF for bachelor's programmes in colleges, universities and HEIs in general. A Core Expert Committee (CEC) was constituted to formulate the modalities for developing the LOCF in various subjects being taught in the undergraduate courses in sciences, humanities, commerce and professional courses. The CEC also constituted the Subject Expert Committees (SEC) in various subjects to prepare detailed guidelines for the LOCF in subjects concerned.

The key components of the planning and development of LOCF are given in terms of clear and unambiguous description of the Graduate Attributes (GA), Qualification Descriptors (QD), Program Learning Outcomes (PLO) and Course Learning Outcomes (CLO) to be achieved at the end of the successful completion of each undergraduate program to be offered by HEIs. In undergraduate education in Information Technology, the programme of study leading to the degree of B.Sc. in Information Technology is discussed herewith.

The Qualification Descriptors (QD), Program Learning Outcomes (PLO) and the Course Learning Outcomes (CLO) were also finalized keeping the broad requirement of the programme in view. The LOCF also gives general guidelines for the Teaching Learning Process (TLP) corresponding to each component of theory, experiment, tutorials, projects and industrial / field visits to be followed in order to achieve the stated outcomes for each component. Finally, some suggestions for using various methods in the assessment and evaluation of learning levels of students are also made. It is a student centric framework where they are expected to learn fundamentals of Information Technology along with the latest trends and techniques like Artificial Intelligence, Internet of Things, Machine Intelligence along with advanced skillsets that include Mobile Application Development, Object Oriented Programming among many other courses.

The Learning outcome-based curriculum framework (LOCF) has been prepared to support designing uniform, advanced and effective Chemistry curriculum for postgraduate studies in Chemistry. The recommendations related to curriculum development is applicable for college/university education system which includes heads of schools/departments, practicing teachers, parents, employers, academics from tertiary institutions, professionals from related fields or related bodies and representatives from university/college examinations authorities. The LOCF guides are based on the consultation documents on curriculum framework of University Grants Commission and MOOCs. The concerns, needs and interests of students, teachers as well as

societal expectations have been taken into consideration while developing these framework structures. Each subject content aims to present a curriculum framework, specifying the curriculum aims, learning targets and objectives, and thus providing suggestions regarding curriculum planning, learning and teaching strategies, assessment and resources. In addition, the curriculum framework also provides examples of effective learning, teaching and assessment practices. A coherent understanding of the postgraduate chemistry curriculum planning and the planning of student learning ability at subject levels can be established. Curriculum development is a collaborative and an on-going enhancement process, therefore, the same shall be updated and improved from time to time to meet new needs of students, teachers and society at large.

The template as developed has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards core courses and discipline specific elective courses with special focus on communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills. The template of learning outcome based curriculum has categorically mentioned defined expected outcomes for the programme like core competency, communication skills, critical thinking, effective skills, problem-solving, analytical reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness and so on along with very specific learning course outcomes at the starting of each course. Therefore, this template on Learning Outcomes based Curriculum Framework (LOCF) for M.Sc. with Chemistry will definitely be a landmark in the field of outcome based curriculum construction.

1. Introduction

Academics and research in India is a priority which depends upon the quality of education. Quality higher education includes innovations that can be useful for efficient governance of higher education institutions, systems and society at large. Thus, fundamental approach to learning outcome-based curriculum framework emphasizes upon demonstration of understanding, knowledge, skills, attitudes and values in particular programme of study. The LOCF based programme intended to follow flexibility and innovation in design of the programme, its assessment, and expect graduate attributes demonstrating the level of learning outcome. It is further expected to provide effective teaching – learning strategies including periodic review of the programme and its academic standard. The learning outcome-based curriculum framework for M.Sc. degree in Chemistry is intended to provide a broad framework and hence designed to address the needs of the students with chemistry as the core subject of study. The framework is expected to assist in the maintenance of the standard of chemistry degrees/programmes across the country and periodic programme review within a broad framework of agreed/expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The framework is intended to allow flexibility and innovation in programme design, syllabi development, teaching-learning process and quality assessment of students learning levels.

This curriculum framework for the master-level program in Chemistry is developed keeping in view of the student centric learning pedagogy, which is entirely outcome-oriented and curiosity-driven. To avoid wrote-learning approach and foster imagination, the curriculum is more leaned towards self-discovery of concepts. The curriculum framework focuses on pragmatist approach whereby practical application of theoretical concepts is taught with substantial coverage of practical and field works. The platform aims at equipping the post-graduates with necessary skills for Chemistry-related careers, careers with general post-graduate-level aptitude and for higher education in Chemistry. Augmented in this framework are graduate attributes including critical thinking, scientific reasoning, moral, ethical reasoning and so on, qualification descriptors that are specific outcomes pertinent to the discipline of chemistry, learning outcomes for the programmes these frameworks have been developed, learning outcomes for individual courses, pedagogical methods and assessment methods.

While designing these frameworks, emphasis is given on the objectively measurable teaching-learning outcomes to ensure employability of the post-graduates. In-line with recent trends in education section, these frameworks foster implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, MOOCs and other e-learning platforms. In addition, the framework pragmatic to the core; it is designed such a way to enable the learners implementing the concepts to address the real world problems. A major emphasis of these frameworks is that the curriculum focuses on issues pertinent to India and also of the west; for example, green chemistry and biomaterials etc. Above all, these frameworks are holistic and aim to mould responsible Indian citizen to have reflective thinking, scientific temper, and digital literacy in order to acquire requisite skill to be self-employed entrepreneurial.

Aims:

1. To transform curriculum into outcome-oriented scenario
2. To develop the curriculum for fostering discovery-learning
3. To equip the students in solving the practical problems pertinent to India
4. To adopt recent pedagogical trends in education including e-learning, flipped class, hybrid learning and MOOCs
5. To mould responsible citizen for nation-building and transforming the country towards the future

1.1 Types of courses and Course structure

Each program may have three types of courses namely Core courses, Eelective courses and Self-study/Skill-based courses

1.1.1 Core Courses

The Core courses are those courses whose knowledge is deemed essential for the students registered for a particular Master's degree program. Where feasible and necessary two or more programs may prescribe one or more common core courses.

- The core courses shall be mandatory for all the students registered for the master's degree program.
- The core courses shall be spread all the semesters of the program.

1.1.2 Elective courses

The elective courses can be chosen from a pool of papers. These courses are intended to

- allow the student to specialize in one or more branches of the broad subject area;
- help the student to acquire knowledge and skills in a related area that may have applications in the broad subject area;

- help the student to bridge any gap in the curriculum and enable acquisition of essential skills, for example, statistical, computational, language, communication skills etc.
- help the student to pursue area of interest
- The student may also choose additional elective courses offered by the college to enable him /her to acquire extra credits from the discipline or across the discipline

1.1.3 project work

A course (core/elective/self-study/skill based) may take the form of a project work.

2 Learning Outcomes - Based Approach to Curriculum Planning and Development (LOACPD):

Curriculum is the heart of any educational system. It can be focused either to achieve the objectives of each course of the programme or on the expected learning outcomes from each course. The objective based curriculum refers to the overall targets to be achieved through curriculum which may be long term or immediate. On the other hand, the learning outcome based curriculum is very specific in nature in terms of changes in the cognitive, affective and psychomotor behavior of the students as a result of their exposure to the curriculum. The outcome based curriculum provides the teacher very specific targets which he can achieve through the selected instructional process as compared to the objective based curriculum which provides general outcomes.

The learning outcome based curriculum has very close relationship with the learning of the students whereas objective based curriculum focusses on only providing knowledge to the students. In other words, higher cognitive skills are developed through learning outcome based curriculum. Hence, it is preferred to develop learning outcome based curriculum which will provide specific directions to the teacher with respect to the transaction process and expected changes in the behavior of the students as well. Based on higher order cognitive skills, achievable targets are performed through individual development of student's performance. Industry ready students are moulded through use of LOCF methodology to achieve the expected outcome.

2.1 Nature and extent of the M.Sc Chemistry Programme

Chemistry is referred to as the science that systematically study the composition, properties, and reactivity of matter at atomic and molecular level. The scope of chemistry is very broad. The key areas of study of chemistry comprise Organic chemistry, Inorganic Chemistry, Physical Chemistry, Electro Chemistry, Green and Nano Chemistry, Spectroscopy and Analytical Chemistry. Organic chemistry is a study of substances containing carbon mostly; inorganic chemistry deals with study of all other elements/compounds/substances and their chemical properties. Physical chemistry deals with applications of concepts, laws to chemical phenomena. Analytical chemistry, in general, deals with identification and quantification of materials. Development of new interdisciplinary subjects like nano-materials, biomaterials, etc. and their applications from chemistry point of view added new dimension to materials chemistry.Thus, the

PG degree programme in chemistry also intended to cover overlapping areas of chemistry with physics, biology, environmental sciences. Further, a broad range of subjects such as materials chemistry, biomaterials, nano-materials, environmental chemistry, etc., has also been introduced which can be helpful for students/faculty members to broaden the scope of their studies and hence applications from job prospective point of view. Therefore, as a part of efforts to enhance employability of post-graduates of chemistry, the curricula also include learning experience with industries and research laboratories as interns. In addition, industrial visits/industrial projects are encouraged and added to the curriculum in order to enhance better exposure to jobs/employment opportunities in industries, scientific projects and allied sectors.

This modified syllabus has been drafted to enable the students to equip for national level competitive exams that they may attempt in future. In addition, employability of M.Sc. Chemistry graduate is given due importance such that their core competency in the subject matter, both theoretical and practical, is ensured. To expand the employability of graduates, a couple of advanced elective courses are also introduced in this framework.

2.2 Aims of Master's degree programme in Chemistry

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

The aim of Master's degree programme in chemistry is intended to provide:

(i) Specific, advance and balanced knowledge in chemistry in addition to understanding of key chemical concepts, principles and theories.

(ii) To develop students' ability and skill to acquire expertise over solving both theoretical and applied chemistry problems.

(iii). To provide knowledge and skill to the students' thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/entrepreneurship.

(iv). To provide an environment that ensures cognitive development of students in a holistic manner. A complete dialogue about chemistry, chemical equations and its significance is fostered in this framework, in addition to real life problems as in industries. Proper exploitation in area of organic chemistry with regard to Natural Products would kindle enormous skills for assessments.

(v). To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A chemistry post-graduate as envisioned in this

framework would be sufficiently competent in the field to undertake further discipline-specific studies, research, as well as to begin domain-related employment.

(vi).To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.

(vii).To enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET, GATE and UPSC Civil Services Examination.

3. Graduate Attributes

Attributes of chemistry post-graduate under the outcome-based teaching-learningframework may encompass the following:

a. **Core competency:** The chemistry post-graduates are expected to know the fundamental concepts of chemistry and applied chemistry. These fundamental concepts would reflect the latest understanding of the field, and therefore, are dynamic in nature and require frequent and time-bound revisions.

b. **Communication skills:** Chemistry post-graduates are expected to possess minimum standards of communication skills expected of a science post-graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Post-graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wider audience.

c. **Critical thinking:** Chemistry post-graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.

d. **Psychological skills:** Post-graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self-reflection, goal-setting, interpersonal relationships, and emotional management.

e. **Problem-solving:** Post-graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across the disciplines;

f. **Analytical reasoning:** Post-graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoning etc.

g. **Research-skills:** Post-graduates are expected to be keenly observant about what is going on in the natural surroundings to awake their curiosity. Post-graduates are expected to design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.

h. **Teamwork:** Post-graduates are expected to be team players, with productive co- operations involving members from diverse socio-cultural backgrounds.

i. **Digital Literacy:** Post-graduates are expected to be digitally literate for them to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.

j. **Moral and ethical awareness:** Post-graduates are expected to be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough to distinguish what construes as illegal and crime in Indian constitution. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.

k. **Leadership readiness:** Post-graduates are expected to be familiar with decision- making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.

4. Qualification Descriptors

The qualification descriptors for a Master's degree in Chemistry may include the following:

(i). Systematic and fundamental understanding of chemistry as a discipline.

(ii). Skill and related developments for acquiring specialization in the subject.

(iii). Identifying chemistry related problems, analysis and application of data using appropriate methodologies.

(iv). Applying subject knowledge and skill to solve complex problems with defined solutions.

(v). Finding opportunity to apply subject-related skill for acquiring jobs and self-employment.

(vi). Understanding new frontiers of knowledge in chemistry for professional development.

(vii). Applying subject knowledge for solving societal problems related to application of chemistry in day to day life.

(viii). Applying subject knowledge for sustainable environment friendly green initiatives.

(ix). Applying subject knowledge for new research and technology.

The qualification descriptors for a Master's degree in Chemistry may also include following:

(i). To demonstrate a systematic, extensive and coherent knowledge and understanding of academic fields of study as a whole and its applications and links to disciplinary areas of the study; including critical understanding of the established theories, principles and concepts of a number of advanced and emerging issues in the field of chemistry;

(ii). To demonstrate procedural knowledge that creates different types of professionals in the field of chemistry. Further application of knowledge can enhance productivity of several economically important product. Knowledge of Chemistry is also necessary for the development and management of industry, manufacturing of fine chemicals, etc.

(iii) Developing skills and ability to use knowledge efficiently in areas related to specializations and current updates in the subject

(iv). Demonstrate comprehensive knowledge about chemistry, current research, scholarly and professional literature of advanced learning areas of Chemistry

(v). Use knowledge understanding and skills for critical assessment of wide range of ideas and problems in the field of Chemistry.

(vi). Communicate the results of studies in the academic field of Chemistry using main concepts, constructs and techniques

(vii).Apply one's knowledge and understanding of Chemistry to new/unfamiliar contexts and to identify problems and solutions in daily life.

(viii).To think and apply understanding of the subject of Chemistry, Chemical Sciences in identifying the problems which can be solved through the use of chemistry knowledge.

(ix).To think of the adopting expertise in chemical sciences and solve the problems of environment, green chemistry, ecology, sustainable development, hunger, etc.

5. Program Learning Outcome in Chemistry

Core competency: Students will acquire core competency in the subject chemistry,

(i). Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related chemistry subjects.

(ii).Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.

(iii).The students will be able to understand the characterization of materials.

(iv). Students will be able to understand the basic principle of equipment, instruments used in the chemistry laboratory.

(v).Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry.

(vi). ***Disciplinary knowledge and skill***: A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be capable of using of advanced instruments and related soft-wares for in-depth characterization of materials/chemical analysis and separation technology.

(vii). ***Skilled communicator***: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.

(viii). ***Critical thinker and problem solver***: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

(ix). ***Sense of inquiry***: It is expected that the course curriculum will develop an inquisitive characteristic among the students through appropriate questions, planning and reporting experimental investigation.

(x). ***Team player***: The course curriculum has been designed to provide opportunity to act as team player by contributing in laboratory, field based situation and industry.

(xi). ***Digitally literate***: The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of

chemical simulation software and related computational work.

(xii). ***Ethical awareness/reasoning***: A post-graduate student requires to understand and develop ethicalawareness/reasoning which the course curriculum adequately provide.

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

6. Structure of M.Sc. Course objectives, Learning Outcomes, Contents, Pedagogy Strategies and References

Program Learning Outcomes (PLOs) of M.Sc. CHEMISTRY

After the completion of the M.Sc. Chemistry program, the student will be able to:

PLO 1 Demonstrate comprehensive knowledge and skills in Organic, Inorganic, Physical,analytical and Materials Chemistry and other modern areas of Chemistry.

PLO 2 Demonstrate effective communication skills both orally and in writing using appropriate media/tools. Apply knowledge and experimental skills to synthesize and analyze chemicals / materials of need for domestic and /or industrial domain.

PLO 3 Apply knowledge of chemistry associated with critical thinking to achieve sustainable solutions for energy and environment and complex problems in day-to-daylife.

PLO 4 Demonstrate intellect inquiry and ability to define problems; use research methods,analyze, interpret and draw conclusions from data; plan, execute and report the results of an experiment or investigation in intra/interdisciplinary areas of chemistry.

PLO 5 Design & Develop eco-friendly procedures for chemical processes in the industry. With acquired skills, critically evaluate practices, rules, and theories based on empirical evidence for relevant quantitative and/or qualitative interpretation.

PLO 6 Demonstrate the capability to use computational tools, software and databasesrelevant to fields of Chemistry in finding solution to complex problems, and, also the ability of self-learning and lifelong-learning using ICT and Open Education Resources to meet industrial demands.

PLO 7 Demonstrate ability to work effectively with diverse teams, facilitate cooperative effort as a member or leader of a team to achieve the transferrable/deliverables.

PLO 8 Demonstrate the ability to identify ethical issues related to one's work, avoid unethical behaviour such as committing plagiarism, not adhering to intellectualproperty rights, and adopt objective and truthful actions in all aspects of work.

PLO 9 Demonstrate knowledge of the values of multiple cultures and a global perspectiveeffectively to engage in a multicultural society for job trades, employment opportunities or further studies.

Annexure – 8

6. M.Sc., CHEMISTRY - SCHEME OF EXAMINATIONS: CBCS PATTERN
(For the students admitted during the academic year 2021-2022 and onwards)

SEM	Sub. code	SUBJECT TITLE		Hrs. Per week	MARKS					No. of credits
					CA	SE	TOTAL	SE-MIN	TPM	
I	**21MCH11C**	Paper I	Inorganic Chemistry – I: *Ring compounds, Non-aqueous solvents & Nuclear Chemistry*	5	50	50	100	25	50	05
	21MCH12C	Paper II	Organic Chemistry – I: *Aromaticity and Organic Reaction Mechanisms*	5	50	50	100	25	50	05
	21MCH13C	Paper III	Physical Chemistry – I: *Quantum Chemistry and Group Theory*	5	50	50	100	25	50	05
II	**21MCH21C**	Paper IV	Inorganic Chemistry – II: *Co-ordination Chemistry*	5	50	50	100	25	50	05
	21MCH22C	Paper V	Organic Chemistry – II: *Photochemistry, Pericyclic reactions, Carbonyl addition, Molecular rearrangements, and Stereochemistry*	5	50	50	100	25	50	05
	21MCH23C	Paper VI	Physical Chemistry – II: *Thermodynamics*	5	50	50	100	25	50	05
	21MCH24P	Practical I	Inorganic Chemistry - I	5	50	50	100	25	50	04
	21MCH25P	Practical II	Organic Chemistry - I	5	50	50	100	25	50	04
	21MCH26P	Practical III	Physical Chemistry – I	5	50	50	100	25	50	04

III	**21MCH31C**	Paper VII	Organic Chemistry – III: *Nomenclature, Reagents, Synthetic Methodology, Oxidation, Reduction and spectral problems*	5	50	50	100	25	50	05
	21MCH32C	Paper VIII	Physical Chemistry – III: *Electrochemistry and Chemical Kinetics*	5	50	50	100	25	50	05
	21MCH33E	Paper IX –E1*	Organic Spectroscopy	5	50	50	100	25	50	04
	21MCH34E	Paper X- E2*	*Green Chemistry, Nano Science and Research Methodology*	3	50	50	100	25	50	03
IV	**21MCH41C**	Paper XI	Organic Chemistry – IV: *Chemistry of Natural Products*	5	50	50	100	25	50	05
	21MCH42E	Paper XII-E3*	Analytical and Solid-State Chemistry	5	50	50	100	25	50	04
	21MCH43E	Paper XIII-E4*	Applied Electrochemistry	5	50	50	100	25	50	04
	21MCH44P	Practical IV	Inorganic Chemistry - II	4	50	50	100	25	50	04
	21MCH45P	Practical V	Organic Chemistry - II	4	50	50	100	25	50	04
	21MCH46P	Practical VI	Physical Chemistry – II	4	50	50	100	25	50	04
	21MCH47V	PROJECT AND VIVA VOCE		3	50	50	100	25	50	06
TOTAL							**2000**			**90**

CA- Continuous Assessment, **SE**- Semester Examination

SE-MIN- Passing minimum in the Semester Examination; **TPM** – Total passing minimum

***E1, E2, E3 & E4 are ELECTIVE PAPERS**

Industrial visit, up to three days, is included in I & III semesters (optional)

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	**I**	**21MCH11C**	**Paper I - INORGANIC CHEMISTRY – I:** *Ring compounds, Non-aqueous solvents & Nuclear Chemistry*	**5**

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

CLO- 1 Recall inorganic ring compounds and interpret need for correlation between sulphur-nitrogen as well organo silicon and silanes.

CLO- 2 Infer the structure of borazine compounds. Recreate the framework of structures using Wade's rules.

CLO- 3 Analyze about reactions in non-aqueous solvents and acid-base theories.

CLO- 4 Apply the principles of HSAB in reactions of importance.

CLO- 5 Summarize the various aspects of nucleus, particles, and radioactive decay, nuclear conversion

CLO- 6 Infer functioning of counters and accelerators.

CLO- 7 Assess on the particle capture, fertile isotopes and carbon capture.

CLO- 8 Explain the applications of radioactive isotopes, neutron activation, isotope dilution analysis.

UNIT-I **(15 hrs)**

Ring Compounds: Borazines, phosphonitrilic compounds, sulphur-nitrogen compounds, organo silicon compounds, silanols, siloxanes, silyl amines (silazenes).

Borane and its derivatives – correlation between structure and number of electrons involved in bonding in the framework - Wade's rules – *closo*, *nido*, *arachno* and *hypho* structures.

UNIT-II **(15 hrs)**

Reactions in Non-aqueous Solvents: Classification of solvents – properties of ionizing solvents – a general study of the typical reactions in liquid ammonia, sulphur dioxide, anhydrous hydrogen fluoride, DMF, and DMSO comparative study.

Acid-Base Concepts: Bronsted-Lowry theory, Lux-Flood concept, Lewis's concept, Usanovich definition, Hard and soft acids, and bases- HSAB concept-principle and applications.

UNIT-III **(15 hrs)**

Nuclear Chemistry: The nucleus – subatomic particles and their properties – binding energy- n:p ratios in stable and metastable nuclei – Different types of nuclear forces – Liquid drop model and Shell model. Modes of radioactive decay – Theory of alpha decay, beta decay, and gamma radiation. Orbital electron capture, nuclear isomerism – Internal conversion.

UNIT-IV **(15 hrs)**

Counters and Accelerators: Cloud chamber, Nuclear emulsion, Bubble chamber, Proportional counters, G M counter, Scintillation, and Cherenkov counters,

Linear accelerators – Cyclotron, Synchrotron, Betatron, and Bevatron.

UNIT-V **(15 hrs)**

Nuclear Reactions: Q – value, coulombic barrier – nuclear cross-section – different types of nuclear reactions- projectile capture – particle emission, spallation, fission, and fusion – Product distributions – theories of

fission, use of fission products, fissile and fertile isotopes- U-238, U-235, Pu-239, Th-232 – Stellar energy, Carbon cycle, H-H chain reaction.

Radio Isotopes: Applications – isotopes as tracers – Neutron activation analysis and Isotopic dilution analysis – uses in structure and mechanistic studies – carbon dating - Hot-atom chemistry-Safety measures*-Disposal of nuclear waste*.

PRACTICALS: Solvents in inorganic complex preparation.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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WEBSITE(S)

- https://ndl.iitkgp.ac.in

- Microsoft Word - 4.doc (bioline.org.br)
- Slide 1 (iitd.ac.in)
- Metal Clusters (dalalinstitute.com)
- https://www.youtube.com/watch?v=O377ShVgLi0&list=PLFW6lRTa1g82yuaxHUfC72ZPBViN95T-D&index=1
- https://www.youtube.com/watch?v=Xs7SFulW4oE&list=PLXLBkCN7a8rn9Em3D5CRAOANhjwvC4CUK&index=1
- https://youtu.be/FFAKGyBNc04
- https://nptel.ac.in/courses/104/103/104103069/
- https://nptel.ac.in/courses/104/104/104104101/
- https://nptel.ac.in/courses/112/103/112103243/

Table 1

Programme Level outcomes	Core Course Level Outcomes (CLOs)							
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7	CLO 8
Disciplinary Knowledge	☑		☑	☑			☑	
Communication Skills	☑				☑			
Critical thinking			☑	☑			☑	
Research- related skills		☑			☑			☑
Analytical reasoning				☑				☑
Problem solving		☑				☑	☑	
Team work				☑		☑		
Moral and ethical awareness		☑				☑		
Multicultural competence		☑						☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	**I**	**21MCH12C**	**Paper II - ORGANIC CHEMISTRY – I:** *Aromaticity and Organic Reaction Mechanisms*	**5**

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

CLO- 1 Summarize the basics of Aromaticity of Organic compounds and to distinguish between Benzenoid and non-benzenoid aromatic compounds.

CLO- 2 Explain Non-kinetic methods and Kinetic methods. Analyze linear free energy relationship in terms of Hammett and Taft equations.

CLO- 3 Identify different types of organic reactions and their mechanisms, which will be useful to find newer route in synthesizing compounds of medicinal values/interest compounds.

CLO- 4 Discuss the reaction mechanisms in Electrophilic and Nucleophilic substitution reactions in aromatic and aliphatic compounds.

CLO- 5 Analyze stereochemistry– Reactivity– regioselectivity : NGP

CLO- 6 Evaluate the various rearrangement reactions through aromatic nucleophilic substitutions.

CLO- 7 Assessment of elimination reactions with respect to certain naming reactions. Illustration on the structure and functions of carbenes and nitrenes.

CLO- 8 Discuss the mechanisms involved on certain naming reactions with respect to addition and free radicals.

UNIT-I **(15 hrs)**

Aromaticity: Criteria - Huckel's rule – diatropic molecules-Aromaticity of Benzenoids and aromatic heterocyclic compounds. Non-benzenoid aromatics – azulene, ferrocene, tropolone, sydnones, and annulenes (synthesis not required) - Non-aromatic and anti-aromatic systems.

Study of Organic Reaction Mechanism: Non-kinetic methods – product analysis intermediate criteria (isolation, trapping, and detection) - isotopic labelling and cross over experiments-stereochemical evidence - energy profile diagrams – intermediate vs. transition state. Kinetic methods - mechanistic implications of rate law - isotope effects – kinetic and thermodynamic control of reactions – Hammond's postulate – linear free energy relationship - Hammett and Taft equations.

UNIT - II **(15 hrs)**

Aromatic Electrophilic Substitution: Mechanism, orientation, and reactivity in mono and disubstituted benzenes- partial rate factors. Specific reactions - Friedel - Craft's alkylation and acylation – Formylations (Gattermann, Gattermann-Koch, Reimer-Tiemann, Kolbe's, Vilsmeier-Haack), Bischler-Napieralski, Hofmann-Martius, and Jacobson reactions.

Aliphatic Electrophilic Substitution: SE^1, SE^2 and SE^i mechanisms - Friedel-Craft's acylation at olefinic carbon - Stork-enamine reaction - decarboxylation of aliphatic acids.

UNIT - III **(15 hrs)**

Aliphatic Nucleophilic Substitution: SN^1, SN^2, ion-pair, SN^i mechanisms-neighbouring group participation – stereochemistry – Reactivity - effect of substrate structure, nucleophile, leaving group, and the reaction medium - ambient nucleophiles (regioselectivity) and ambient substrate- hydrolysis of esters.

Aromatic Nucleophilic Substitution: SN^1, SNAr and benzyne mechanisms - structure and reactivity -

effect of substrate structure, leaving groups and nucleophile -typical reactions - Bucherer, Rosenmund, Von-Braun, Ziegler, Chichibabin reactions - Von-Richter, Sommlett – Hauser and Smiles rearrangements.

UNIT - IV **(15 hrs)**

Elimination Reactions: E_1, E_2, and E_1cB mechanisms-structural and stereochemical factors governing eliminations, Hofmann and Saytzeff rule – Bredt's rule –elimination vs. substitution-pyrolytic eliminations-Chugaev reaction-Hofmann degradation - Cope elimination, Shapiro reaction-Extrusion reactions

Carbenes and Nitrenes - Structure, generation, and reactions.

UNIT – V **(15 hrs)**

Addition Reactions: Electrophilic, Nucleophilic, and free radical addition to double and triple bonds-hydration, hydroxylation (OsO_4, $KMnO_4$, H_2O_2, Woodward & Prevost methods), Michael addition, Hydroboration, and Epoxidation- Sharpless asymmetric epoxidation, Skraup synthesis.

Free Radicals: Free radicals –generation of short-lived and long-lived free radicals- detection of free radicals- addition, substitution, elimination, and rearrangement reactions of free radicals- typical reactions: Sandmeyer, Gomberg-Bachmann, Ullmann, Pschorr and Hunsdieker reactions.

PRACTICALS: Aromatic Electrophilic Substitution – Nitration, Bromination
Addition Reaction – Bromination, $KMnO_4$

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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- https://www.youtube.com/watch?v=hsBn-BxuN0M
- https://www.youtube.com/watch?v=RtV_JxzZoss
- https://www.youtube.com/watch?v=-D8tYR3LTsI

- https://nptel.ac.in/courses/104/101/104101115/
- https://nptel.ac.in/courses/104/101/104101005

Table 2								
Programme Level outcomes	**Core Course Level Outcomes (CLOs)**							
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**	**CLO 6**	**CLO 7**	**CLO 8**
Disciplinary Knowledge	☑	☑	☑				☑	
Communication skills			☑		☑			☑
Critical thinking	☑		☑		☑			☑
Research- related skills			☑			☑	☑	
Analytical reasoning		☑		☑				☑
Problem solving	☑			☑				☑
Team work					☑		☑	
Moral and ethical awareness		☑	☑			☑		
Multicultural competence		☑						☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	**I**	**21MCH13C**	**Paper III - PHYSICAL CHEMISTRY – I:** *Quantum Chemistry and Group Theory*	**5**

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

CLO- 1 Explain the concepts of Quantum chemistry principles, postulates, and illustration of Schrodinger equation.

CLO- 2 Apply the basic ideas in solving particle in 1D, 3D box system, ring and sphere.

CLO- 3 Extending the acquired knowledge in solving harmonics, rigid rotor. Apply the approximation methods to solve hydrogen atom, Helium in ground and excited state.

CLO- 4 Demonstrate the MO methods, HMO methods. Assessment on bonding in many electron systems.

CLO- 5 Identify symmetry and point groups for varied molecules. Discussion on postulates and GMT.

CLO- 6 Develop knowledge on creation of irreducible representation and character table for C_{2v} and C_{3v}

CLO- 7 Evaluate selection rules for vibration of small molecules and splitting of orbitals in O_h, T_d

CLO- 8 Simplify MO calculations using SALC's

UNIT – I **(15 Hrs)**

Quantum Chemistry: Basic Concepts – Black body radiation - Time-dependent and time-independent Schrodinger equation – requirement of an acceptable wave function – operator concept as applied to quantum mechanics (basic ideas) - postulates of quantum mechanics – Hermitian operators – application of Schrodinger equation to the particle in a box (1D & 3D Boxes) – Particle in a ring & Particle in Sphere

UNIT - II **(15 Hrs)**

Application to Hydrogen Atom Problem: Harmonic oscillator and rigid rotator – Central force problem – H-atom – method of separation of variables – final solution – the energy and wave function for the problem – quantum numbers – shapes of the wave functions – electron spin and Pauli's principle

Approximation Methods: Approximate methods in quantum mechanics – the need for approximation methods – Perturbation and variation methods applicable to H_2 molecule in the ground and excited states – He atom in the ground state, He_2^+ in the ground and excited state.

UNIT – III **(15 Hrs)**

Bonding in Many Electron Systems: LCAO – MO methods – Slater determinants – HMO treatment of conjugated and straightforward π- electron systems – ethylene, allyl, butadiene, and benzene systems – delocalization energy – construction and use of hybrid orbitals – directional character – determination of bond angles.

UNIT – IV **(15 Hrs)**

Group Theory & Molecular Symmetry: Molecular symmetry and group theory – Point symmetry – Schonfloes and Herman-Mauguin notations – identification of point groups of simple molecules – postulates of group theory – group multiplication table – orthogonality and irreducible representations – application of the orthogonality theorem to obtain the irreducible representations of the point groups C_{2v} and C_{3v} only – character table (explanation) different areas of the character tables.

UNIT – V **(15 Hrs)**

Group Theory & Normal Modes of Vibrations, Orbital Splitting: Application of the group theoretical methods to find the total number of vibrations of simple molecules such as H_2O and NH_3 – Selection rules with regard to Raman and IR activities and electronic transitions – splitting of orbitals in O_h, T_d and D_{4h} symmetries – hybridization as applied to methane and water – simplification of MO calculations employing symmetry adopted linear combination molecular orbital procedure – application to Butadiene.

A minimum of 10% problem-oriented questions to be asked

PRACTICALS: Interpretation of vibration from IR data using Group theory principles.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizzes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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- https://www.youtube.com/watch?v=p82enyv3XA0
- https://www.youtube.com/watch?v=_MCbWJa4u-4
- https://www.youtube.com/watch?v=AYRuPNK6WNM
- https://www.youtube.com/watch?v=gLesbQ8MPlU
- https://www.youtube.com/watch?v=ASPuNKrCzDE

Table 3								
Programme Level outcomes	**Core Course Level Outcomes (CLOs)**							
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**	**CLO 6**	**CLO 7**	**CLO 8**
Disciplinary Knowledge	☑	☑		☑	☑	☑		☑
Communication skills		☑		☑			☑	
Critical thinking	☑		☑		☑			☑
Research- related skills		☑			☑		☑	
Analytical reasoning			☑	☑		☑		
Problem solving		☑		☑		☑		
Team work		☑			☑		☑	
Moral and ethical awareness		☑				☑		☑
Multicultural competence	☑			☑				☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	**II**	**21MCH21C**	**Paper IV - INORGANIC CHEMISTRY – II:** *Co-ordination Chemistry*	**5**

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

CLO- 1 Illustrate on bonding both MOT and CFT : Use of spectrochemical series.

CLO- 2 Assign various symmetries for Octahedral, Tetrahedral and square planar using group theory. CFSE effects.

CLO- 3 Analyze term symbols –microstate. Demonstrate both Orgel and Tanabe- Sugano diagrams

CLO- 4 Critiques on John-Teller tetragonal distortions and – Nephelauxetic effect.

CLO- 5 Analyze Structural aspects of metal carbonyls – Use of Vaska's compound

CLO- 6 Identify ring systems of 5, 7and 8 membered. Extrapolate to complexes of Heme, myo and cyanocobalamine and metallo-enzymes

CLO- 7 Summarize Ligand substitution reaction in octahedral complexes – Mechanism. Design on Trans effect – Theories – Electron transfer

CLO- 8 Utilize reagents/reactions in conversions.-hydroformylation, carbonylation. Application of Wacker process and Ziegler- Natta polymerization.

UNIT – I **(15 Hrs)**

Types of ligands – nomenclature and isomerism

Bonding: Valence bond theory-Crystal field theory – crystal field effects in tetrahedral, octahedral, and square planar symmetries – Crystal field stabilization energy – weak and strong field effects – spectrochemical series

MOT & CFT: Molecular Orbital Theory-based on group theoretical approach MO diagrams of O_h, T_d and square planar symmetries with and without π bonding – experimental evidence for the presence of π bonding – Magnetic behaviour of the transition metal ions in crystal field and molecular orbital theories.

UNIT – II **(15 Hrs)**

Term symbols: Microstates and Term symbols, characteristic of d-d transitions and selection rules. Weak and strong field limits – Energy level diagrams – Orgel and Tanabe- Sugano diagrams – Orgel diagram for Co^{2+} ion in tetrahedral and octahedral fields – Orgel diagram for d^2, d^3, d^7 & d^8 systems in octahedral and tetrahedral fields - Tanabe-Sugano diagrams for d^2 to d^8 systems (d^2, d^3, d^4, d^5, d^6, d^7 & d^8) - John-Teller tetragonal distortions and spin-orbit couplings – Nephelauzetic effect – charge transfer spectra.

UNIT – III **(15 Hrs)**

Organo metallic compounds: Metal carbonyls, methods of preparation, structure, bonding, and reactions – carboxylate ions – carbonyl hydrates, carbonyl halides – Vaska's compound – Compounds of molecular nitrogen and oxygen – Nitrosyl complexes, β-diketones, – Complexes of unsaturated hydrocarbons alkenes, allyls, and dienyls.

UNIT –IV **(15 hrs)**

Carbocyclic π –Complexes: Cyclopentadienyl and related complexes (synthesis, bonding, structure, and reactions) – Arene complexes: Complexes formed by seven and eight-membered aromatic rings

Complexes of Biochemical Importance: Porphyrin ring system, Cytochromes, Haemoglobin, Myoglobin,

Cyanocobalamine, Chlorophyll (structure and functions, PS-I & II), Sodium and Potassium ion pumps-nitrogen fixation-Metal poisons and chelating agents in medicine - Metallo enzymes.

UNIT – V **(15 hrs)**

Reactions of Co-ordination Compounds: Ligand substitution reaction in octahedral complexes – Mechanism of nucleophilic substitution reaction in octahedral and square planar complexes – Trans effect – Theories – Electron transfer reactions in co-ordination compounds – Theory of redox reactions.

Homogenous Catalysis of Co-ordination Compounds: Hydroformylation, Carbonylation of methanol and methyl acetate, Hydrogenation of unsaturated organic compounds, Wacker process – Ziegler- Natta polymerization.

PRACTICALS: Preparation of square planar complexes - mechanism

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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Table 4								
Programme Level outcomes	**Core Course Level Outcomes (CLOs)**							
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**	**CLO 6**	**CLO 7**	**CLO 8**
Disciplinary Knowledge	☑	☑	☑		☑	☑		
Communication Skills		☑				☑		☑
Critical thinking	☑		☑	☑			☑	
Research- related skills		☑		☑		☑	☑	
Analytical reasoning	☑	☑			☑	☑		
Problem solving	☑		☑				☑	
Team work			☑	☑				
Moral and ethical awareness				☑		☑		☑
Multicultural competence					☑			☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	II	21MCH22C	**Paper V - ORGANIC CHEMISTRY – II:** *Photochemistry, Pericyclic reactions, Carbonyl addition, Molecular rearrangements, and Stereochemistry*	5

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

CLO- 1 Interpret Jablonski diagram, thermally activated delayed fluorescence (TADF)

CLO- 2 Illustrate of Norrish Type I, Norrish Type II. Need for di – π methane rearrangement

CLO- 3 Develop theory on the Woodward – Hoffmann rules – Correlation diagrams

CLO- 4 Evaluate arrangement towards Sigmatropic shifts, Claisen and Cope.

CLO- 5 Explain on addition reactions to carbonyl compounds – naming reactions

CLO- 6 Assess molecular rearrangements and synthesis of certain compounds

CLO- 7 Apply chirality for sulphur and nitrogen compounds, to biphenyls, allenes spiranes.

CLO- 8 Exercise on E Z notation and application of configuration and conformation

UNIT-I **(15 hrs)**

Organic Photochemistry: Theory of light absorption –electronic excitation - properties & energies of excited states – Jablonski diagram – photo physical processes – fluorescence, delayed fluorescence (E & P types), Thermally activated delayed fluorescence (TADF) and Phosphorescence - Excimers and Exciplexes – intersystem crossing – inter & intramolecular energy transfer - Quantum efficiency.

Photochemical reactions of ketones – Norrish Type I, Norrish Type II – Paterno – Buchi reaction – Photoreduction and oxidation – α, β- unsaturated ketones- Photochemistry of olefins, conjugated olefins and aromatic compounds – *cis-trans* isomerisation - di – π methane rearrangement of cyclohexdienones – Barton's reaction.

UNIT –II **(15 hrs)**

Pericyclic Reactions: classification – Theories – The Frontier Orbital approach – The Woodward – Hoffmann rules – Correlation diagrams, Huckel – Mobius approach, Dewar – Zimmermann approach, Electrocyclic reactions of 1,3-dienes and 1,3,5-trienes, [2+2] and [4+2] cycloadditions, Diels – Alder reaction, Retro Diels – Alder reaction, 1,3 – dipolar addition – Cheleotropic reaction. Sigmatropic reactions – [1,3], [1,5] and [3,3], Sigmatropic shifts – Claisen and Cope rearrangements, ene reactions.

UNIT III **(15 hrs)**

Addition Reactions to Carbonyl Compounds: Mannich, Aldol, Grignard, Claisen & Dieckmann, Stobbe, Perkin, Knoevenagel, Darzen, Wittig, Thorpe, Reformatsky, and Benzoin reactions, Friedlander quinoline synthesis, Strecker and Peterson synthesis. Stereo selectivity in carbonyl addition reactions - Cram's rule.

UNIT IV **(15 hrs)**

Molecular Rearrangements & Applications: Migratory aptitudes- Memory effects. Migration to electron deficient carbon: Wagner – Meerwein, Demyanov, Dienone – phenol rearrangements, Wolff (Arndt-Eistert synthesis), Favorski. Rearrangement to electron-deficient nitrogen: Neber, Lossen and Schmidt rearrangements. Rearrangement to electron-deficient Oxygen: Baeyer–Villiger. Aromatic Rearrangements: Fries. Electrophillic Rearrangements: Steven's. Non-cyclic rearrangements: Chapman and Wallach rearrangement. Sigmatropic rearrangements: Benzidine, Fischer-indole synthesis.

UNIT V **(15 hrs)**

Stereochemistry: Optical isomerism – Concept of chirality- Stereochemistry of sulfur and nitrogen compounds – concept of prochirality- enantiotopic and diastereotopic ligands & faces- stereo selective and stereo specific reactions - R, S – nomenclature of compounds having one and more than one chiral centres – axial chirality - (optical isomerism of biphenyls, allenes and spirans)- planar chirality (optical isomerism of ansa compounds and cyclophanes) - helicity (optical isomerism of over – crowded molecules)

Geometrical Isomerism: E, Z – notation – Determination of configuration of geometrical isomers- stereoisomerism of cyclic compounds (up to six membered ring)– aldoximes & ketoximes.

Conformational Analysis: Configuration and conformation – Conformation of acyclic compounds – cyclohexanes, decalins – stability and reactivity in relation to conformation – perhydrophenanthrenes.

PRACTICALS: Rearrangement reactions – Mannich, Claisen, Perkin and Konevenagel.
Functional group analysis.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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Table 5								
Programme Level outcomes	**Core Course Level Outcomes (CLOs)**							
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**	**CLO 6**	**CLO 7**	**CLO 8**
Disciplinary Knowledge	☑	☑	☑		☑	☑	☑	
Communication skills		☑			☑		☑	☑
Critical thinking			☑	☑		☑		
Research- related skills		☑	☑			☑	☑	
Analytical reasoning		☑	☑	☑		☑		
Problem solving		☑	☑			☑		
Team work				☑	☑			
Moral and ethical awareness			☑		☑	☑		
Multicultural competence					☑	☑		

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	**II**	**21MCH23C**	**Paper VI - PHYSICAL CHEMISTRY – II:** *Thermodynamics*	**5**

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

CLO- 1 Differentiate between activity and its co-efficient in liquids and gases.

CLO- 2 Specifically use fugacity for gases and apply the same to liquid mixtures.

CLO- 3 Categorize the forms of molecular gas distribution. Apply to heat capacity calculations

CLO- 4 Compile the need for third law of thermodynamics. Importance of probability.

CLO- 5 Perform theoretical interpretation on various distribution laws.

CLO- 6 Carry out entropy calculation of gas through B-E and F-D statistics.

CLO- 7 Develop Einstein's and Debye's Theories of Heat Capacities

CLO- 8 Assess partition functions, evaluate Sackur – Tetrode Equation.

UNIT – I **(15 Hrs)**

Activity: Activity and activity co-efficient - determination of activity co-efficient - standard states.

Fugacity: Definition – determination – Graphical, Equation of States and Approximate method of Calculation – Variation of fugacity with Temperature and Pressure – Fugacity of Real and Ideal Gases – Mixture of Real Gases – Determination of Fugacity in Gas Mixtures (The Lewis – Randall Rule) – Variation of Fugacity with T & P for mixture of gases. Fugacity in Liquid Mixtures

UNIT – II **(15 Hrs)**

Quantum Statistics – Molecular Gas Distribution: Maxwell Distribution Law for Molecular velocities – for Ideal Gas – Evaluation of Average Velocity (C_{av}), – Root Mean Square Velocity (C_{RMS}), Most Probable Velocity (C_{MPV}), – Distribution Function in terms of the Kinetic Energy for Ideal gas – Experimental Verifications of Maxwell Distribution – the Principle of Equipartition of Energy and the Calculation of Heat Capacities of Ideal Gases and Limitations

UNIT – III **(15 Hrs)**

III Law of Thermodynamics and Entropy: Probability and III Law of Thermodynamics – Need for III Law – Nernst Heat Theorem and Other Statements of III Law – Thermodynamic Quantities at Absolute Zero – Statistical Meaning of III Law – Apparent Exceptions – Helium at Low Temperature – Negative Absolute Temperature – Entropy of Gases – Entropy at Absolute Zero – Entropy and Probability (Boltzmann Expression) – Boltzmann – Planck Equation – Significance of Thermodynamic Probability – Entropy of Expansion of Ideal Gas.

UNIT – IV **(15 Hrs)**

Statistical Concepts and Thermodynamic Distributions: Theories of permutations and combinations – law of probability - distribution law – Guassian distribution – Binomial distribution.

Thermodynamic Probabilities of Systems involving Energy Levels – Maxwell-Boltzmann Distribution law – Evaluation of α and β in Maxwell- Boltzmann Distribution Law (Lagrangian Multipliers). Bose – Einstein and Fermi – Dirac Statistics – Bose – Einstein Distribution Law – Entropy of Bose – Einstein Gas – Fermi – Dirac gas – comparison, Heat Capacity of the Electron Gas and Heat Capacity of Metals- Calculation of Fermi energy for gold and copper.

UNIT V **(15 Hrs)**

Quantum Statistics for Solids: Einstein's and Debye's Theories of Heat Capacities of Solids – Maxwell-Boltzmann Statistics – Phase Space – Thermodynamic Probabilities of Systems in Equilibrium – Boltzmann Expression of Entropy – Stirling's approximation – States of maximum thermodynamic probability.

Partition function: Definition – Justification & Nomenclature – Barometric Distribution Law – Boltzmann Distribution – Relation between Total Partition Functions & Translational, Rotational Vibrational & Electronic Partition Functions – *Ortho & para*-Hydrogen – Evaluation of Thermodynamic Properties (E, H, A and G, C_V and C_P, – Entropy of Monoatomic Molecules (Sackur – Tetrode Equation) and Calculation of Equilibrium Constants of Reactions.

A minimum of 10% problem-oriented questions to be asked

PRACTICALS: Determination of activity and activity co-efficient.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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Table 6

Programme Level outcomes	Core Course Level Outcomes (CLOs)							
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7	CLO 8
Disciplinary Knowledge	☑		☑	☑	☑	☑	☑	
Communication skills			☑					
Critical thinking	☑	☑			☑		☑	☑
Research- related skills		☑	☑	☑		☑	☑	
Analytical reasoning	☑		☑			☑		☑
Problem solving		☑		☑	☑		☑	
Team work			☑					☑
Multicultural competence				☑				

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	**III**	**21MCH31C**	**Paper VII - ORGANIC CHEMISTRY – III:** *Nomenclature, Reagents, Synthetic Methodology, Oxidation, Reduction and spectral problems*	**5**

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

CLO- 1 Correlate between acyclic and monocyclic compounds. Learn the naming of bicyclic systems.

CLO- 2 Identify the suitable reagents for synthetic conversions of various organic compounds.

CLO- 3 Recognize synthons and equivalents. Develop Retrosynthetic approach in the synthesis of organic target molecules.

CLO- 4 Illustrate functional group interconversions (FGI)

CLO- 5 Perform organic conversions through oxidation reagents.

CLO- 6 Use specific reagent in oxidizing alkenes.

CLO- 7 Summarize reductive process through reducing agents in conversions.

CLO- 8 Possess through knowledge on interpretation of spectral data available through application of various instrumental techniques. Predict the correct structure using various spectra.

UNIT I **(15 hrs)**

Nomenclature: IUPAC nomenclature of acyclic and monocyclic compounds-

Nomenclature of bicyclic system – large ring compounds (muscone, civetone), Novel ring system – adamantane – diadamantane, cubane (strained ring), catenane (interlocked system), Bulvalene (fluxional molecule)

(Synthesis only for catenanes, synthesis for others not necessary)

Reagents in Organic Synthesis: Hexamethylphosphorictiamide (HMPT), 1,5- diaza-bicyclo[5,4-c]-undecene-3 (DBU), Polyphosphoric acid (PPA), 1,3-dithiane (umpolung), Lithium dimethylcuprate (LDC), Lithium disopropylamide (LDA), Crown ethers, Phase transfer catalysts (PTC), Merrifield resin, Trimethylsilyliodide.

UNIT II **(15 hrs)**

Synthetic Methodology: Retrosynthesis – disconnection approach – Synthons and synthetic equivalents – guidelines for choosing disconnections– linear and convergent synthesis – controlling and enhancing the reactivity - functional group interconversions – functional group addition - one group C-X disconnections – two group C-X bond disconnections – one group C-C bond disconnections – regioselectivity – two- group C-C bond disconnections - 1,3- difunctional, 1,5 – difunctional compounds and Robinson annelation reaction - importance of the order of events – Chemoselectivity – reversal of polarity. Protecting groups – protection of alcohols, carbonyl groups, carboxylic group and amino group. Modern methods of functional group interconversions (FGI) involving >C=O, -CHO, OH, SH, -COOH, >C=C<, $-NH_2$, -COOR, -CONHR functions. Synthetic examples: β-vetivone, Vitamin A and longifoline

UNIT III **(15 hrs)**

Oxidation: Jone's reagent, Pyridinium chlorochromate (PCC), Pyridinium dichromate (PDC), Chromyl chloride, Dioxiranes, Dicyclohexylcarbodiamide (DCC), DMSO, DMSO-Ac_2O, DMSO-oxalyl chloride (Swern reaction), Oppenaur oxidation, Sommelet reaction - oxidative cleavage of 1, 2 – diols (lead tetra acetate and

periodic acid), Etard reaction, Dichlorodicyanobenzoquinone (DDQ), SeO_2, Ozonolysis, Lemieux reagents ($NaIO_4$ with $KMnO_4$ & OsO_4), allylic oxidation (SeO_2 & NBS), Fenton's reagent, Oxidation of amines and sulphides, Wacker process (ketone from alkene) and Ceric ammonium nitrate (CAN).

UNIT IV **(15 hrs)**

Reduction: Catalytic hydrogenation – typical reactions – catalysts and solvents, catalytic dehydrogenation.

Metal hydride reduction – typical reactions and conditions used – $LiAlH_4$, $NaBH_4$ and $NaCNBH_3$ reductions, Hydroboration, 9-BBN, tri –n- butyltin hydride (TBH), DIBAL–H, Me_3SiCN, tri tertiarybutoxy aluminum hydride, Stereochemistry of reduction of cyclic ketones with metal hydrides.

Dissolving metal reductions – Birch reduction, Clemmensen reduction, electro-organic reduction, Wolff-Kishner, Meerwein-Pondorff-Verley and Rosenmund reduction, McMurrays coupling, Cannizzaro reaction, Acyloin condensation, Wilkinson's catalyst, Baker's yeast.

UNIT V **(15 hrs)**

Problems based on Spectra: Applications of Elemental Analysis, UV, IR, ^1H NMR and Mass spectral techniques to solve the structures of simple organic molecules (problems based on data).

PRACTICALS: Retrosynthetic analysis of a given compound,
Oxidation reactions & Reduction reactions
Interpretation of UV, IR, NMR Spectra

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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Table 7								
Programme Level outcomes	**Core Course Level Outcomes (CLOs)**							
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**	**CLO 6**	**CLO 7**	**CLO 8**
Disciplinary Knowledge	☑	☑	☑	☑	☑		☑	
Communication skills			☑		☑			
Critical thinking		☑	☑					☑
Research- related skills				☑		☑		
Analytical reasoning	☑		☑			☑		☑
Problem solving		☑		☑			☑	
Team work			☑					☑
Moral and ethical awareness						☑		
Multicultural competence				☑				

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	III	21MCH32C	**Paper VIII - PHYSICAL CHEMISTRY – III:** *Electrochemistry and Chemical Kinetics*	5

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

CLO- 1 Demonstrate the activity co-efficient through electrochemical analysis. Concentration dependence in evaluating DHO equation.

CLO- 2 Compare thermodynamic parameters from electrochemical reactions.

CLO- 3 Calculate the kinetics at the electrode-electrolyte interface.

CLO- 4 Acquire the basics of membrane potentials outlined through kinetic phenomenon.

CLO- 5 Gain knowledge on the charge transfer in electrode reactions, its reversibility to the ions.

CLO- 6 Explain the techniques of uni- and bi- molecular processes. Application of steady state approximation in transient species in chain reactions.

CLO- 7 Examine the mechanism of enzyme catalysis, polymerization kinetics, Heterogeneous catalysis – adsorption.

CLO- 8 Interpret the potential energy diagram and Langmuir isotherms.

UNIT – I **(15 hrs)**

DHLL and Electrode potential: Calculation of heat of solvation, Hydration of ionic species – Ionic strength – concentration and activity coefficient – Debye-Huckel limiting law- Electrochemical Method of determining activity coefficients of electrolytic solutions – Electrolytic conductance – Debye-Huckel-Onsager equation – verification – Wien effect and Debye-Falkenhagen effect – Thermodynamics of electrochemical reactions – Free energy and emf – Standard and formal electrode potentials – Problems based on electrode potentials and their measurements – Ion selective electrodes.

UNIT – II **(15 hrs)**

Electrode Kinetic phenomena: Electrode – Electrolytic interface – electrical double layer – electrocapillary thermodynamics – Lippman equation – Measurements of double layer capacitances – Theoretical models of double layers – Helmholtz and Guoy-Chapman models – Potential of zero charge – Stern model – outer and inner Helmholtz planes – Specific adsorption of cations, anions and neutral molecules – a brief outline of Electrokinetic phenomenon and membrane potentials.

UNIT – III **(15hrs)**

Electrode Kinetics: Kinetics of electron transfer – Butler-Volmer equation – the transfer coefficient – double layer effects – The Tafel equation – Charge transfer resistance – Reversibility and irreversibility in electrochemical reactions – Nernst relation from Butler-Volmer relation – multi-step process – the effect of electrode on electron transfer rate – Hydrogen evolution reaction as a case study – processes associated with electron transfer – mass transfer effects – over-voltages - activation concentration and resistance over-voltage.

UNIT – IV **(15hrs)**

Chemical Kinetics: The ARRT – thermodynamic treatment of ARRT – significance of reaction co-ordinate – application of ARRT – Unimolecular and bimolecular processes – Potential energy surface – Kinetic isotopic effect – Principles of microscopic reversibility – Steady State Approximation – Third order and termolecular reactions – Applications of ARRT to solution kinetics – Factors affecting reaction rates in solution.

Chain reactions and explosions – Homogeneous catalysis, Acid – base catalysis – salt effects – acidity functions – Zucker-Hammet hypothesis – Bunnett criterion.

UNIT – V **(15 hrs)**

Enzyme catalysis: Mechanism of single substrate reaction – influence of pH and temperature – fast reactions – chain reaction (water only)– Kinetics of polymerization in solution – Heterogeneous catalysis – adsorption and free energy relation at interfaces – Gibbs's adsorption isotherm – Physical adsorption – Chemisorption – Potential energy diagram and Lennard-Jones plots – Langmuir and BET isotherms – Measurement of surface area – Semiconductor catalysis – Langmuir – Hinshelwood and Langmuir – Rideal – Eley mechanisms

A minimum of 10% problem-oriented questions to be asked

PRACTICALS: DHLL- Electrochemical Method of determining activity coefficients.
Acid hydrolysis of an ester. Saponification.
Adsorption experiments

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizzes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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Table 8

Programme Level outcomes	Core Course Level Outcomes (CLOs)							
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7	CLO 8
Disciplinary Knowledge	☑		☑	☑	☑		☑	
Communication skills			☑		☑			☑
Critical thinking		☑		☑	☑	☑		
Research- related skills		☑	☑	☑				
Analytical reasoning	☑							☑
Problem solving	☑	☑		☑		☑	☑	
Team work		☑						☑
Moral and ethical awareness							☑	
Multicultural competence							☑	

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	III	21MCH33E	Paper IX - Elective Paper - I: ORGANIC SPECTROSCOPY	5

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

CLO- 1 Analyze the spectral regions in EMR. Know-how of vibrational frequencies.

CLO- 2 Outline instrumentation technique on IR and characteristic absorption frequencies of functional groups.

CLO- 3 Correlate electronic structure with molecular structure. Interpret absorption of chromophores in visible region.

CLO- 4 Apply Woodward-Fieser rules for calculating absorption maxima

CLO- 5 Utilize various techniques of NMR spectroscopy- Heteronuclear coupling, double resonance.

CLO- 6 Perform NMR interpretation through numerical – solutions to problem-DEPT spectra

CLO- 7 Apply knowledge on Correlation NMR Spectroscopy – learning theoretical calculations.

UNIT – I **(15 hrs)**

Energy and electromagnetic spectrum: Units, Electromagnetic spectrum and absorption of electromagnetic radiation.

Infrared Spectroscopy: The vibrating diatomic molecules – the simple harmonic oscillator – the diatomic rotator – vibrations of polyatomic molecules – the influence of rotation on the spectrum of polyatomic molecules – Molecular vibrations – calculation of vibrational frequencies - modes of vibrations- Factors influencing vibrational frequencies – vibrational coupling, hydrogen bonding, electronic effects, bond angles and field effects - Instrumentation- FT- IR spectrometer – Sampling techniques - Characteristic group absorptions of organic molecules-identity by finger printing and identification of functional groups – Applications – medical diagnosis(cancer).

UNIT –II **(15 hrs)**

Ultraviolet and Visible Spectroscopy: Electronic spectra of diatomic molecules – Laws of photometry – Theory of electronic spectroscopy – Instrumentation and sample handling - Correlation of electronic structure with molecular structure – Simple chromophoric groups – Solvent effects - Effects of conjugation – Woodward – Fieser rules – Aromatic system and systems with extended conjugation – Applications.

UNIT – III **(15 hrs)**

^{1}H NMR Spectroscopy: The NMR phenomenon -Magnetic properties of nuclei – theory of nuclear magnetic resonance – Chemical shift and its measurement – Instrumentation –CW and FT NMR spectrometer – pulse techniques and Fourier transforms – Advantages of FT NMR - Factors influencing chemical shift – electronegativity, Vander Waals deshielding and anisotropic effects - Chemical equivalence and magnetic equivalence – Influence of restricted rotation - solvents used in NMR – Solvent shifts - Spin –Spin coupling – Theory of spin-spin splitting – AX &, AX_2 systems. More complex spin-spin splitting systems - AX_3, A_2X_3 and AMX systems. Proton exchange reactions – Factors influencing coupling constants - Heteronuclear coupling – Deuterium exchange – Non-first order spectra – Simplification of complex proton NMR spectra – Increased field strength, double resonances and chemical shift reagents – Applications.

UNIT – IV **(15 hrs)**

^{13}C NMR Spectroscopy: Magnetic moment and natural abundance- broad band decoupling-deuterium coupling- NOE effect- Off-resonance decoupling- peak assignments using DEPT spectrum – structural applications of ^{13}C NMR spectroscopy.

Correlation NMR Spectroscopy- theory- ^{1}H-^{1}H COSY, ^{1}H-^{13}C COSY: HETCOR, Proton-detected HETCOR: HMQC, Proton-Detected Long-Range ^{1}H-^{13}C Heteronuclear Correlation: HMBC, NOESY

UNIT – V **(15 hrs)**

Mass Spectrometry: Theory – Instrumentation – Isotopic abundance – Determination of molecular weights and formulae, Ionisation techniques (CI, FD, FAB,ESI, MALDI-TOF) – Nitrogen rule – Metastable ions and peaks – LCMS, HRMS -Ion fragmentation mechanisms – Retro Diels-Alder rearrangement – Mclafferty rearrangement – Fragmentation associated with functional groups – alcohols, carbonyl compounds, amines, ether and aromatic compounds, elimination due to ortho groups.

PRACTICALS: Data interpretation and structural characterisation from IR, UV, NMR & Mass spectra of organic compounds.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizzes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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Table 9

Programme Level outcomes	Skill based Course Level Outcomes (CLOs)						
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7
Disciplinary Knowledge	☑		☑	☑	☑	☑	
Analytical reasoning		☑		☑			
Research- related skills		☑	☑	☑		☑	
Scientific reasoning	☑	☑		☑	☑		
Information/digital literacy			☑	☑		☑	
Problem solving	☑		☑		☑		☑
Cooperation/ Team work				☑			
Moral and ethical awareness	☑			☑			☑
Self-directed learning	☑	☑	☑		☑		☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	III	21MCH34E	Paper X - Elective Paper -2: GREEN CHEMISTRY, NANO SCIENCE AND RESEARCH METHODOLOGY	3

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

CLO- 1 Outline the methodology of principles of green chemistry, use of greener solvents, appreciate the utility of microwave and PTC

CLO- 2 Open up with new avenues of supramolecular chemistry, crown ethers, catenanes

CLO- 3 Predict the host –guest chemistry, solid state supramolecular chemistry. Zeolites, MOF

CLO- 4 Practice preparative procedures for nanomaterial synthesis.

CLO- 5 Use various characterization techniques in characterization of nanomaterials.

CLO- 6 Plan a research topic on the basis of literature survey. Review articles assessment.

CLO- 7 Write a scientific paper

UNIT – I **(7hrs)**

Green Chemistry Principles: Introduction - Definition, need of green chemistry, twelve basic principles of green chemistry – Greener solvents – supercritical carbon dioxide – water as solvent -solvent free synthesis- reactions in ionic-liquid, solid supported organic synthesis, phase transfer catalyst (PTC), use of microwaves and sonication (any four specific reactions with mechanism).

UNIT – II **(8 hrs)**

Supramolecular Chemistry: Introduction – Selectivity – Lock and key principle and induced fit model – Podand and Macrocycle – Preorganisation. Supramolecular interactions: Ion-Ion interactions, Ion-dipole interactions, Dipole-dipole interactions, Hydrogen bonding, cation-π- anion-π interactions, π-π stacking, Vanderwalls interactions. Solution Host–Guest Chemistry- Crown ether, Hydride sponge, Cyclodextrin – cation, anoin and neutral molecule binding (introductory aspects). Supra molecular structures – mechanically interlocked molecules - catenanes and rotaxanes. Solid state supramolecular chemistry – zeolite, clathrate, metal organic frameworks (introductory aspects)

UNIT – III **(8 hrs)**

Nano Science: Introduction- definition-quantum confinement-classification of nano materials. Properties and Size dependence of properties:- Chemical, Optical (Plasmon resonance), vibrational, thermal, Electrical, Magnetic, Theoretical Aspects –Basics of density functional theory.

Growth Techniques of Nano materials: Bottom up and Top-down approaches- methods of preparation of nano materials – plasma arching, chemical vapour deposition, electro spinning, electrodeposition, PLD, sol-gel synthesis, ball-milling and Lithographic Techniques –Electron Beam.

UNIT –IV **(7 hrs)**

Chemical Synthesis of Nano materials: Chemical reduction (borohydride, citrate and polyol), high temperature thermal decomposition, liquid-liquid interface reaction, solution state polymerization, Green synthesis.

Characterization Tools of Nano materials: Instrumentation, principle , applications and limitations of

powder XRD, Scanning Electron Microscopy (SEM- EDX), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM) and Scanning Transmission Electron Microscopy (STEM)

Applications of Nano materials: In catalysis, environmental and biomedical (drug delivery) applications. Nano materials-Toxic effects -environmental hazards

Wealth out of waste (WTW)

UNIT – V **(15 hrs)**

Research Methodology: Problem selection- literature survey-primary sources-journals, patents, journals of different fields of chemistry (organic, inorganic, physical, polymer, analytical and nano) - secondary sources-books, indexes, chemical abstracts, review articles - literature searching online.

Writing a project report: Style and conventions – title, abstract, introduction, review of literature, experiments, results and discussion, foot notes, figures, presenting data, tables, summary and bibliography.

Scientific paper writing: Definition of Scientific writing, title, abstract, introduction, materials and methods (experiments), results, discussion, conclusions, acknowledgments, literature cited (References), keywords for indexing, publication ethics-plagiarism.

Citation index: SCI, WOS, Scopus, impact factor, h-index, i10 index. IPR.

PRACTICALS: Phase transfer catalysis- rate, order determination.
Nanomaterial synthesis- hydrothermal processes.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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11. Jacob Israelachvili - Intermolecular and Surface Forces
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- https://nptel.ac.in/courses/118/102/118102003/
- https://nptel.ac.in/courses/121/106/121106007/
- https://www.youtube.com/watch?v=Yzfl3rtF0SM
- https://www.youtube.com/watch?v=-emrdVazBN8

Table 10							
Programme Level outcomes	**Skill based Course Level Outcomes (CLOs)**						
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**	**CLO 6**	**CLO 7**
Disciplinary Knowledge	☑	☑		☑	☑		
Analytical reasoning				☑	☑		☑
Research- related skills		☑			☑	☑	
Scientific reasoning			☑		☑		
Information/digital literacy		☑	☑	☑		☑	
Problem solving		☑	☑		☑		☑
Cooperation/ Team work				☑	☑		
Moral and ethical awareness			☑	☑		☑	☑
Self-directed learning	☑	☑	☑		☑		☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	IV	21MCH41C	**Paper XI - ORGANIC CHEMISTRY – IV:** *Chemistry of Natural Products*	5

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

CLO- 1 Demonstrate the classification of terpenoids. Compile isoprene rules.

CLO- 2 Establish the structure of natural products. Hint on the biosynthesis of terpenoids.

CLO- 3 Elucidate certain type of steroids as well as biosynthesis of steroids.

CLO- 4 Determine the structure of alkaloids and synthetic route for preparation of alkaloids.

CLO- 5 Recreate the types of peptide linkage. Primary structures of peptides.

CLO- 6 Revise the primary and secondary structures of proteins. Assess the structure of DNA. Learn the basic of hormones and enzymatic nomenclature

CLO- 7 Examine the synthesis and reactions of purines and structural elucidation.

CLO- 8 Evaluate the need for antibiotics with structural elucidation.

UNIT – I (**15 hrs**)

Terpenoids: Isolation and classification –isoprene & special isoprene rules, methods of structural elucidation and synthesis as applied to zingiberine, β-eudesmol, Caryophyllene, Santonin and abietic acid – Biosynthesis of terpenoids.

UNIT – II **(15 hrs)**

Steroids: Types and definition - structural elucidation of cholesterol (synthesis not necessary), ergosterol, vitamin–D, oestrone, Equilenin, Progesterone, Androsterone and Testosterone– Biosynthesis of steroids – Bile acids.

UNIT – III **(15 hrs)**

Alkaloids: General methods for determining structure - structural elucidation, synthesis and biosynthesis of the following alkaloids: Reticuline, Glaucine, Morphine, Quinine, Narcotine, Reserpine, Acronycine and Tylophorine.

UNIT – IV **(15 hrs)**

Peptides: The peptide linkage, Primary structure of peptides – C-terminal & N-terminal amino-acid determinations-partial hydrolysis of peptides-protein subunits, cyclic structures and disulphide bonds- summary of primary structure determination-solid-phase peptide synthesis.

Proteins: Primary, Secondary and Tertiary structures of proteins. Structure of DNA and RNA and their biological importance- biosynthesis of proteins.

Harmones: Structure and functions of Thyroxine, Oxytocin, Insulin and TRH (synthesis not required)

Enzymes: Nomenclature and classification – Cofactors-Nicotinamide-adenine dinucleotide (NAD^+) - Nicotinamide-adenine dinucleotide phosphate ($NADP^+$)-Adenosine triphosphate- specificity of enzyme action-mechanism of enzyme action-enzyme inhibitors.

UNIT – V **(15 hrs)**

Heterocyclic Compounds: Synthesis and reactions of purines – (adenine and guanine) and pyrimidines (barbituric acid, uracil, thymine and cytosine) anthocyanine and flavones (cyanidine chloride, flavone, quercetin).

Anti-biotics – Structural elucidation, synthesis and applications of penicillins and chloramphenicol.

PRACTICALS: Isolation and characterisation of a few natural products.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.

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- https://youtu.be/AYB_E9gdzx0
- https://youtu.be/2DyeKE5q8Go
- https://youtu.be/pel8P2atSEg

Table 11

Programme Level outcomes	Core Course Level Outcomes (CLOs)							
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7	CLO 8
Disciplinary Knowledge	☑		☑	☑	☑		☑	
Communication skills	☑		☑					☑
Critical thinking		☑	☑	☑				
Research- related skills		☑		☑				☑
Analytical reasoning	☑					☑		☑
Problem solving		☑	☑	☑				
Team work		☑		☑		☑		☑
Moral and ethical awareness		☑			☑		☑	
Multicultural competence				☑			☑	

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	IV	21MCH42E	Paper XII - Elective Paper - 3: ANALYTICAL AND SOLID-STATE CHEMISTRY	5

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

CLO- 1 Summarize and use various thermal methods in analysis of samples. Outline the technical methodology for sample testing using refractometry, turbidimetry and nephlometry

CLO- 2 Identify the types and use of fluorometers and phosphorometers.

CLO- 3 Compare and contrast the chromatographic techniques in chemical analysis. Analyze sample with AAS and FES.

CLO- 4 Utilize the theoretical aspects on solid state materials- semiconductors and superconductors. Adapt to characterization using XRD and electron diffraction.

CLO- 5 Analyze samples using Circular Dichroism and ORD and Cotton effects. Utilize instrumentation techniques with ESCA, AES and UPS.

CLO- 6 Investigate mossbauer spectra.

CLO- 7 Discuss the principles of ESR. Predict the hyperfine splitting.

UNIT – I **(15 hrs)**

Thermal analysis: Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) – principle, instrumentation and applications.

Refractometry- Refractometer theory – basic principle – Abbe Refractometer – Applications.

Turbidimetry and Nephelometry: Principle, Instrumentation and applications.

Molecular fluorescence and phosphorescence: Principle and theory – Fluorometers – Phosphorometers – Instrumentation and applications.

UNIT II **(15 hrs)**

Chromatography: Principle, theory, instrumentation and applications in chemical analysis of the following – column, paper, thin layer and ion-exchange – GC, GC-MS, GLC and HPLC. Purification of common organic solvents.

Atomic absorption spectroscopy and Flame emission spectroscopy: Basic principle – Instrumentation and applications. Comparison between AAS, AFS, ICP-OES and FES

UNIT III **(15 hrs)**

Metallic State: Free electron, band and zone theories-non-stoichiometry – point defects in solids- Schottky and Frenkel defects* – linear effects – dislocation – effects due to dislocation – electrical properties of solids – insulators – intrinsic and extrinsic semiconductors (n & p type) and super conductors, ceramics (elementary treatment)

Chemical Crystallography: Diffraction methods – X-ray, neutron and electron Diffraction – Structure of NaCl, KCl and CsCl – Determination of lattice type and unit Cell dimensions – Power Camera – indexing the powder pattern – An elementary discussion of structural factors and scattering factor – Structures of Rutile, Fluorite, Antifluorite, zinc blende, Wurtzite, Diamond and Graphite.

UNIT IV **(15 hrs)**

Polarimetry: Circular Dichroism and Optical rotatory dispersion –Basic principles of ORD and CD – Cotton effects – Octant rule – axial halo ketone rules - applications of ORD and CD

Photoelectron Spectroscopy: ESCA (XPS): principle, chemical shifts-description of ESCA spectrometer, X-ray sources, samples, analysis, detectors and recording devices –applications. Auger electron spectroscopy (AES) and UV photo electron spectroscopy (UPS) – principle, applications and instrumentation.

UNIT V **(15 hrs)**

Mossbauer Spectroscopy: Principles – Spectrometer – Isomer shift – Quadruple interaction – Nuclear Zeeman Splitting – Applications

ESR Spectroscopy: Theory – Derivative curves – 'g' shift – hyperfine splitting – Isotropic and anisotropic systems – Zero field splitting and Kramer degeneracy – Identification of free radicals – Applications.

PRACTICALS: Interpretation of TG/DTA
Chromatographic techniques – TLC, Paper

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models and Brain storming activity.
- Visiting Central Instrumentation Laboratories and Hands-on training.

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- https://www.youtube.com/watch?v=r55anTcoWvE
- https://www.youtube.com/watch?v=X3AHbeZhKhU

Table 12

Programme Level outcomes	Skill based Course Level Outcomes (CLOs)						
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7
Disciplinary Knowledge	☑		☑		☑		☑
Analytical reasoning	☑				☑		
Research- related skills		☑	☑			☑	
Scientific reasoning	☑			☑			☑
Information/digital literacy			☑	☑		☑	
Problem solving			☑				☑
Cooperation/ Team work		☑		☑			
Moral and ethical awareness	☑			☑			☑
Self-directed learning	☑		☑				☑

Year	Sem.	Subject Code	Title of the paper	Hours/ Week
2021 -2022 onwards	IV	21MCH43E	Paper XIII - Elective Paper - 4: APPLIED ELECTROCHEMISTRY	5

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

CLO- 1 Develop to interpret voltammograms obtained from various electroanalytical techniques.

CLO- 2 Extrapolate the electrochemical reactions in electrosynthesis of valuable chemicals

CLO- 3 Analyze the operations in electrometallurgical processes of refining fine chemicals. Specific reference to Hall-Heroult process

CLO- 4 Evaluate the performance of electroplating technique as applied to fabrication process of aluminum

CLO- 5 Carry out research on batteries- primary and secondary cells. Apply to rechargeable cells with more specificity to nickel-cadmium cells.

CLO- 6 Work on Design of corrosion control technique, kinetics of corrosion and oxidation of metals.

CLO- 7 Practice on evaluation of corrosion control and corrosion inhibitors and related processes.

UNIT – I **(15 hrs)**

Electroanalytical techniques: Current–voltage relationships – mass transfer – diffusion limited currents – kinetic currents – adsorption currents – Polarography – DC and pulse polarographic methods – Cyclic voltametry – Rotating disc electrodes – Chronoamperometry – Chronopotentiometry – Chronocoulometry (Basic principles and applications only in all the above methods)

UNIT – II **(15 hrs)**

Electrochemical cells: Components of electrochemical cells – Types of cells – divided and undivided cells – Chlor-alkali cells mercury, diaphragm and membrane cells – electro-inorganic chemicals – Chlorates, perchlorates – electrosynthesis of fluorine – electro-organic chemicals – electro-reduction of nitro and carbonyl groups – Kolbe electrolysis – electrodimerisation – adiponitrile.

UNIT – III **(15 hrs)**

Electrometallurgy and Electroplating: Electro winning and electro refining of Cu and Ni, production of aluminium – Hall-Heroult process – Electrolytic production of magnesium and sodium – Electroplating operations – Preplating operations – electroplating of Nickel and Chromium – precious metal plating (Ag, Au & Pt)– anodizing of Al.

UNIT – IV **(15 hrs)**

Batteries: Thermodynamics of batteries and fuel cells – half cell reactions in batteries – characteristic requirements of a battery system – components of batteries – porous electrodes – separators –evaluation of batteries – charge – discharge characteristics – primary batteries, lead acid batteries – Leclanche cells - lithium cells – Ni-Cd cells – High temperature batteries – sodium-sulphur system.

UNIT –V **(15 hrs)**

Corrosion and its Control: Thermodynamics of corrosion – Pourbaix diagrams – kinetics of corrosion – evans diagram – corrosion current and corrosion potential – Metal oxidation – atmospheric corrosion – crevice

corrosion – bimetallic corrosion – stress corrosion – cracking – corrosion control and corrosion inhibitors – painting for corrosion control – cathodic protection – protection by sacrificial anodes.

PRACTICALS: Conductometric experiments.
Determination of single electrode potentials.

PEDAGOGY STRATEGIES

- Chalk and Talk Lecture
- Power point Presentation with Animation
- Group Discussions
- e-Content
- Seminar
- Quizes
- Assignments
- Virtual Classroom
- Create models

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Table 13

Programme Level outcomes	Skill based Course Level Outcomes (CLOs)						
	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7
Disciplinary Knowledge	☑	☑	☑	☑	☑	☑	
Analytical reasoning		☑					
Research- related skills	☑		☑				☑
Scientific reasoning		☑			☑		
Information/digital literacy	☑		☑	☑		☑	
Problem solving	☑		☑		☑		
Moral and ethical awareness	☑			☑			☑
Self-directed learning	☑	☑			☑		

PRACTICALS

For each of the papers:

Total Marks =100 (Internal = 50 & External = 50)

Distribution of internal Marks:

Continuous assessment (for minimum of ten experiments) = 30

Model examination = 05

Record = 15

Distribution of External Marks:

Total = 50 (Record: 05 & Experiment(s): 45)

Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	I & II	21MCH24P	Practical I : INORGANIC CHEMISTRY – I	5

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

CLO- 1 Acquire knowledge about the separation and analysis of mixtures of rare and common cations.

CLO- 2 Apply the method of preparation of complexes.

CLO- 3 Examine the estimation of metal ions using colorimetry.

CLO- 4 Work on methods which are helpful in metal industries.

Qualitative analysis, employing semimicro methods and spot tests of mixtures of common cations and ions of the following less familiar elements.

Thallium, Tungsten, Selenium, Tellurium, Molybdenum, Cerium, Thorium, Titanium, Zirconium, Vanadium, Beryllium, Uranium and Lithium.

About ten preparations involving different techniques selected from the following:

Lead tetra acetate, dipyridinium hexachloroplumbate, hydroxylamine hydrochloride, ortho-and para-hydroxy phenyl mercuric chloride, potassium cupric chloride, chrome alum, copper(I) chloride, trithio urea copper(I), potassium trioxalato-aluminato(III), potassium trioxalato chromate(III), potassium trioxalato ferrate(III), hexamine cobalt(III) chloride, chloro pentammine chromium(III), chloro aquo pentammine chromium(III) nitrate, tetrammine copper(II) sulphate, ammonium hexachloro stanate(IV).

Note: A minimum of five inorganic mixtures, each of two common and two rare elements should be analysed by a student. A minimum of five preparations should be done by a student.

Colorimetric estimations (using Nessler technique and colorimeters) of copper, iron, nickel, manganese and chromium.

Distribution of Marks: **Total = 50 (Record:05 & Experiment(s): 45)**

Qualitative analysis = 25 (Familiar: 5+5 & less familiar: 7.5 + 7.5)
Preparation = 10
Colorimetric estimation = 10

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Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	I & II	21MCH25P	Practical II : ORGANIC CHEMISTRY – I	5

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

CLO- 1 Perform the separation techniques and systematic analysis of organic mixtures

CLO- 2 Distinguish between aromatic-aliphatic, saturated-unsaturated compounds and to find out elements present and functional groups.

CLO- 3 Develop skill for the preparation and recrystallization of organic compounds involving single stage comprising of the following reactions: hydrolysis, acetylation, bromination, nitration, benzoylation and oxidation

Analysis of two component mixtures - Separation and characterization of compounds.

About ten preparations involving single stage comprising of the following processes: nitration, acylation, halogenation, diazotisation, rearrangement, hydrolysis, reduction, alkylation and oxidation and preparations illustrating the following: Benzoin condensation, Cannizzaro reaction, Perkin reaction, Reimer-Tiemann reaction, Sandmeyer reaction, Fries rearrangement, Skraup synthesis – (recrystallisation of product, melting point determination and calculation of percentage yield)

Note: A minimum of six organic mixtures should be analysed by each student. A minimum of five preparations should be done by each student

Distribution of Marks: **Total = 50 (Record: 05 & Experiment(s): 45)**

Qualitative analysis = 35

Pilot separation-**5**, Two components: 2×15 = **30**

(Special elements: 3 × 1 = 3

Aromatic/Aliphatic: 2

Saturated/Unsaturated: 2

Functional group: 5

Derivative: 3

Preparation = 10

(Crude:07, Recrystallisation:03)

REFERENCES:

1. N. S.Gnanapragasam and G. Ramamurthy, Organic Chemistry Lab Manual, S. Viswanathan (printers & Publishers) Pvt. Ltd. (2010)
2. **Vogel's**. Textbook of. **Practical**. **Organic**. **Chemistry**. Fifth edition. |. B. S. Furniss • A. J. hannaford • P. W. G. Smith • A. R. Tatchell.

Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	I & II	21MCH26P	Practical III : PHYSICAL CHEMISTRY – I	5

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

CLO- 1 Find out molecular weight by Rast method and Beckmann method microlevel.

CLO- 2 Determine the emf, standard potential, solubility product, pH and pKa values.

CLO- 3 Recognize the thermal analysis of binary system and 3 component system.

Thermodynamics:

a. Heat of solution from solubility

b. Heat of solution by calorimetry

Molecular weight determination by

i. Freezing point depression of solvents (benzene and water) by Beckmann method.

ii. By Rast micro methods

Distribution of activity and activity co-efficient by freezing point method.

Distribution co-efficient and determination of equilibrium constant.

Properties of matter

Variation of viscosity of liquids with temperature.

Determination of refractive index (Unknown composition of a mixture of liquids).

Heterogeneous equilibria

Thermal analysis of binary systems forming compounds with congruent melting points.

Three component systems (chloroform-acetic acid-water).

Electromotive force

Determination of standard potentials (Cu, Zn, Ag)

Evaluation of thermodynamic quantities from e. m. f. data (Daniel cell).

Determination of pH and pKa values using hydrogen and quinhydrone electrodes and glass electrode (pH meter), potentiometric acid-base titrations.

Determination of formal redox potential of a redox system, redox titrations.

Determination of instability constant (of silver ammonia complex) and its dependence on temperature.

Determination of solubility product of a sparingly soluble salt (concentration cell and chemical cell).

Determination of activity co-efficient from emf. data.

Precipitation titration of a mixture of halides.

Distribution of Marks:

Total = 50 (Record:05 & Experiment(s): 45)

REFERENCES:

1. Yadav, Practical Physical Chemistry
2. S.R. Palit and S. k. de, Practical Physical Chemistry, Science Book Agency, Calcutta
3. V. Venkateswaran, and A. R.. Kulandaivelu, Practical Physical Chemistry, Sultan Chand and & Sons

Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	**III & IV**	**21MCH44P**	**Practical IV: INORGANIC CHEMISTRY – II**	**4**

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

CLO- 1 Acquire knowledge about industrial analysis of brass, bronze, stainless steel, cement and glass and determination of hardness of water.

CLO- 2 Investigate the the preparation of complexes.

CLO- 3 Estimate the metal ions using Volumetric and Gravimetric estimations.

Industrial analysis: a. Analysis of two of the following alloys – brass, bronze, stainless steel, solder type metal. B. Analysis of any one of the following – cement, dolomite, glass.

Titrimetry: Oxidation using ceric and vanadium salts: Complexometric titrations involving estimation of calcium, magnesium, nickel, zinc and Hardness of water.

Chromatography: Column, Paper, Thin layer and Ion exchange.

Titrations in non-aqueous solvents.

Preparation, analysis and study of the properties of co-ordination complexes.

Note: Quantitative analysis (involving Volumetric and Gravimetric estimations) of at least five mixtures of cations should be done by a student. The volumetric procedure may also include EDTA titration for estimation of mixtures of cations.

Distribution of Marks: **Total = 50 (Record:05 & Experiment(s): 45)**

Volumetric analysis = 22.5

Gravimetric analysis = 22.5

<2% = 22.5 marks

2 – 3% = 20 marks (less 0.5 mark for each 0.2 % error)

3 – 4% = 15 marks (less 1 mark for each 0.2% error)

>4% = 10 marks

Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	III & IV	21MCH45P	Practical V: ORGANIC CHEMISTRY – II	4

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

CLO- 1 Apply analytical techniques for the estimation of phenol, aniline, glucose and methyl ketone

CLO- 2 Analysis of oils (Meisel value, Iodine value and Saponification value) and extraction and Estimation of active constituents like lactose from milk etc.

CLO- 3 Develops skill for the preparation of organic compounds involving double stage.

Estimation of Phenol, Methyl ketone, Glucose, and Amino groups.

Analysis of oils (Reichart – Meisel value, Iodine value, Saponification value and acetyl value).

Extraction and estimation of active constituents:

a. Lactose from milk b. Caffeine from tea c. Nicotine from tobacco extract d. Citric acid or ascorbic acid from a tablet or from a natural source.

About five two-stage preparations from literature – (recrystallisation of product, melting point determination, TLC and calculation of percentage yield, Characterisation using IR spectra).

Purification of organic solvents using distillation (any two).

Distribution of Marks: **Total = 50 (Record:05 & Experiment(s): 45)**

Volumetric estimation = 30

<2% = 30 marks

2 – 3% = 25 marks (less 1 mark for each 0.2 % error)

3 – 4% = 15 marks (less 1 mark for each 0.1% error)

>4% = 10 marks

Preparation = 15

Stage I: Recrystallisation = 3 marks

Stage II: Crude = 9 marks, Recrystallisation = 3 marks

REFERENCES:

1. N. S.Gnanapragasam and G. Ramamurthy, Organic Chemistry Lab Manual, S. Viswanathan (printers & Publishers) Pvt. Ltd. (2010)
2. **Vogel's**. Textbook of. **Practical**. **Organic**. **Chemistry**. Fifth edition. |. B. S. Furniss, A. J. Hannaford P. W. G. Smith, A. R. Tatchell.

Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	III & IV	21MCH46P	Practical VI: PHYSICAL CHEMISTRY – II	4

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

CLO- 1 Application of conductance to find out equivalent conductance and verify Debye – Huckel Onsagar law, pKa value and acid-base titrations.

CLO- 2 Develope skill to evaluate Arrhenius parameters using acid hydrolysis of an ester and kinetics of persulphate-iodide reaction.

CLO- 3 Develope skill to prove Freundlich isotherm using adsorption studies.

Conductivity experiments:

Determination of i) Equivalent conductance of a strong electrolyte and the verification of Debye-Huckel Onsagar law. ii) Verification of Ostwald dilution law and Kohlrausch's law for weak electrolytes.

Conductometric determination of pKa of a weak acid.

Hydrolysis constant of aniline hydrochloride.

Determination of the solubility of a sparingly soluble salt.

Conductometric titrations: Acid-base and precipitation titrations (including mixture of halides).

Colorimetric estimation using Beer-Lambert law (copper, nickel).

Dropping mercury cathodes – half-wave potentials and estimations by differential method of cadmium, copper, zinc and lead.

***Chemical kinetics*:**

i. Evaluation of Arrhenius parameters using acid hydrolysis of an ester.

ii. Base catalysed hydrolysis of an ester conductometrically.

Rate of reaction between persulphate and iodide ions study of salt effects over the S_2O_8 – KI reaction.

Study of rate of polymerization of monomer solutions by viscosity.

Evaluation of i) Catalytic constant of a strong acid for the iodination of acetone or hydrolysis of an ester.

ii) Catalytic constants for weak acids and verification of Bronsted catalysis law.

Adsorption experiments: Adsorption of oxalic, acetic, formic acids on activated charcoal – Freundlich isotherm – surface area determination.

Distribution of Marks:

Total = 50 (Record:05 & Experiment(s): 45)

REFERENCES:

1. Yadav, Practical Physical Chemistry
2. S.R. Palit and S. k. de, Practical Physical Chemistry, Science Book Agency, Calcutta
3. V. Venkateswaran, and A. R.. Kulandaivelu, Practical Physical Chemistry, Sultan Chand & Sons.

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Year	Sem.	Subject Code	Subject Title	Hours/ Week
2021 -2022 onwards	IV	21MCH47V	PROJECT AND VIVA VOCE	3

PROJECT:

Total Marks = 100 (Internal = 50 & External = 50)

Internal Marks, 50, to be awarded by the concerned Guide

Distribution of External Marks:

***Viva-voce* Examination = 20 & Project Report = 30**

(Jointly by both Internal & External examiners)

7. Teaching Learning Methodologies

The learning outcomes based course curriculum framework of Chemistry is designed to persuade the subject specific knowledge as well as relevant understanding of the course. The academic and professional skills required for Chemistry-based professions and jobs are also offered by same course in an extraordinary way. In addition, the learning experiences gained from this course should be designed and implemented for cognitive development in every student. The practical associated with this course helps to develop an important aspect of the teaching-learning process. Various types of teaching and learning processes will need to be adopted to achieve the same. The important relevant teaching and learning processes involved in this course are;

a. Class lectures
a. Seminars
b. Tutorials
c. Group discussions and Workshops
d. Peer teaching and learning
e. Question preparation
f. Subjective type
g. Long answer
h. Short answer
i. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
j. Practicum, and project-based learning
k. Field-based learning
l. Substantial laboratory-based practical component and experiments
m. Open-ended project work,
n. Games
o. Technology-enabled learning
p. Internship in industry, and research establishments.

The effective teaching strategies will also need to be adopted to develop problem-solving skills,

higher-order skills of reasoning and analysis. The designed course also encourages fostering the social values/responsibility for maintaining and protecting the surrounding environment forimproved living conditions. A learner centric and active participatory pedagogy shall be introduced in this framework.

8. Assessment Methods

Academic performance in various courses i.e. core, discipline electives, generic electives and skill enhancement courses are to be considered as parameters for assessing the achievement of students in Chemistry. A number of appropriate assessment methods of Chemistry will be used to determine the extent to which students demonstrate desired learning outcomes. Following assessment methodology should be adopted;

The oral and written examinations (Scheduled and surprise tests),

Closed-book and open-book tests,

Problem-solving exercises,

Practical assignments and laboratory reports,

Observation of practical skills,

Individual and group project reports,

Efficient delivery using seminar presentations,

Viva voce interviews are majorly adopted assessment methods for this curricullum.

The computerized adaptive testing, literature surveys and evaluations, peers and self-assessment, outputs form individual and collaborator.

II M. Sc CHEMISTRY – MODEL QUESTION PAPER

PAPER X : Elective Paper 2- Green Chemistry, Nano Science and Research Methodology

Subject code: 21MCH34E **Max marks: 50**

Time: 2Hrs

PART – A (5 x 1 = 5)

ANSWER ALL THE QUESTIONS

I.MULTIPLE CHOICE QUESTIONS

1. Identify the green chemistry principle using solar power
   a. Atom economy b. Design of energy efficiency c. Design benign chemicals
   d. Less hazardous synthesis
2. Choose the one which is related to green chemistry synthesis
   a. High-temperature b. Dichloromethane c. Fossil fuels d. Microwave
3. Recall the length scale used in nanotechnology
   a. Size of the order of 10 -7m b. Size of the order of 10 -7m
   c. Size of the order of 10 -7m d. Size of the order of 10 -7m
4. Recognize the property of Single Walled Carbon Nano Tubes (SWCNT)
   a. excellent conductors b. Poor conductor
   c. Poor conductor than MWCNT d. none
5. Select the one to be avoided in a technical report
   a. Facts b. Logical conclusion c. Objective evaluation d. Subjective evaluation

II.VERY SHORT ANSWERS (3x2 = 6)

(Short answers not exceeding 25 words each)

6. Indicate any four advantages of microwaves in green chemistry.
7. Summarize ionic liquids.
8. Define quantum dots.
9. List out any four applications of nano materials in environmental applications.
10. Give name of any four journals in chemistry.

PART B (5X 3 =15)

ANSWER ALL THE QUESTIONS

Short answers not exceeding 100 words each

11. Write note on planning a green synthesis in a chemical laboratory?
12. Explain solventless reaction with suitable examples.
13. Discuss the applications of nano materials in drug delivery.
14. Describe the principle and instrumentation of Scanning Electron Microscope.
15. What are secondary sources in literature survey?

PART C (3 X 8 = 24)

Answer any three questions not exceeding 750 words

16. Analyze twelve basic principles of green chemistry.
17. Explain the term 'Sonication'. Write any three specific reactions with its mechanism.
18. Discuss the principle, instrumentation and applications of Atomic Force Microscopy.
19. Examine the applications of ESCA to nano material characterization.
20. Prepare a report on primary sources of literature survey.