SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Learning Outcomes based Curriculum Framework

(LOCF)

For

M.Sc. Organic Chemistry (Semester I and II)

Post graduate Programme

From

Academic year

2023-24

Vision & Mission

Mission:

- Equip the student with knowledge and skills of their chosen vocation, Inculcate values.
- Provide them opportunities for all, round growth and prepare them for life.

Vision:

- To equip the students with advanced knowledge and skills in their chosen vocation.
- To provide value-based education and opportunities to students.
- To help them to face challenges in life.
- To nurture a scientific attitude, temperament and culture among the students.
- To continually review, develop and renew the approach to build India of the Founder's dream.

Goals and Objectives:

- To build a strong Academia-Industry bridge.
- To provide flexibility in the courses offered and proactively adapt to the changing needs of students and the society.
- To establish a centre for multidisciplinary activities.
- To mould individuals who would nurture the cultural heritage of our country and contribute to the betterment of the society.

Board of studies in Chemistry

Post graduate

	Name	Designation	Institute/Industry
Head of the Department			
1	Dr.Bright O. Philip	Chairman	K J Somaiya college of science and commerce
Subject Expert nominated by Vice-Chancellor			
1	Prof. B. M. Bhanage (Inorganic chemistry)	Professor, Industrial and Engineering chemistry	ICT, Mumbai
Subject experts			
1	Dr. P A Hassan	Senior Research Scientist	BARC, Mumbai
2	Mr Sanjay Mahimkar	Head, Dept of chemistry	Ruparel College, Mumbai
3	Prof Suresh Pawar	Professor, University department of Chemistry	University Dept of Chemistry
4	Dr Brijesh Kumar Singh	Head, Associate Professor	Jai Hind College
5	Dr Shrikant Nalwade	Technical Leader, Consumer Goods West Asia R&D Scientist	Milliken Chemical & Textile India Company Pvt Ltd.
6	Dr Kalpana Patankar-Jain	Principal	Royal College, Mira Road

Representative from Industry/corporate sector/allied area			
1	Dr. Ajit Datar	Advisor	Shimadzu Analytical (I) Pvt. Ltd, Mumbai
2	Dr Rajesh Rajeshirke	Manager, Global technology & Sourcing	BASF India
Meritorious Alumnus			
1	Dr. Druman Utekar	Assistant Professor	K J Somaiya College of Engineering, Vidyavihar
2	Dr. Rikhil Shah	Lead Analyst , Intellectual Property,	Avient Corporation, USA
	Student representatives		
3	Tanay Desai	Msc II Physical	KJSSC
4	Anachal Pande	Msc	KJSSC
5	Ananya kundu	Msc II Organic	KJSSC
6	Suraj Gupta	Msc II Organic	KJSSC
7	Bhavika Gehlot	Msc I	KJSSC
8	Chinmay Soman	Msc I	KJSSC
9	Geetanjali Khade	MSc II Inorganic	KJSSC
10	Shayona Parmar	MSc II Analytical	KJSSC
Faculty of the specialisation			
1	Dr. Pradnya. J. Prabhu	Principal	K J Somaiya College of Science and Commerce
2	Dr. Bright O. Philip	Head & Associate Professor	K J Somaiya college of science and commerce
3	Dr. Sugandha Shetye	Professor	K J Somaiya college of science and commerce

4	Dr. Chitra Kamath	Associate Professor	K J Somaiya college of science and commerce
5	Dr. Veena Khilnani	Associate Professor	K J Somaiya college of science and commerce
6	Dr. Nishamol Kanat	Associate Professor	K J Somaiya college of science and commerce
7	Dr. Yogesh Ghalsasi	Associate Professor	K J Somaiya college of science and commerce
8	Dr. Vanita Kulkarni	Associate Professor	K J Somaiya college of science and commerce
9	Dr. Saurabh Shete	Assistant Professor	K J Somaiya college of science and commerce
10	Dr. Trupti Tawde	Assistant Professor	K J Somaiya college of science and commerce
11	Dr. Rohit S. Chauhan	Assistant Professor	K J Somaiya college of science and commerce
12	Dr. Aniket Pawanoji	Assistant Professor	K J Somaiya college of science and commerce
13	Dr. Nanabhau Karanjule	Assistant Professor	K J Somaiya college of science and commerce
14	Dr. Dilip Kumar Yadav	Assistant Professor	K J Somaiya college of science and commerce
15	Dr. Afsar Ali Siddiki	Assistant Professor	K J Somaiya college of science and commerce
16	Dr. Mithun Mondal	Assistant Professor	K J Somaiya college of science and commerce

17	Mr. Jaidip Wable	Assistant Professor	K J Somaiya college of science and commerce
18	Dr. Amol Pawar	Assistant Professor	K J Somaiya college of science and commerce
19	Mrs. Mansi Maske	Assistant Professor	K J Somaiya college of science and commerce
20	Mr. Sarang Gujar	Assistant Professor	K J Somaiya college of science and commerce
21	Mrs. Sheetal sonavane	Assistant Professor	K J Somaiya college of science and commerce
22	Mr. Rahul Hegishte	Assistant Professor	K J Somaiya college of science and commerce
23	Mrs. Unnati Maru	Assistant Professor	K J Somaiya college of science and commerce
24	Dr. Sai Prasad Ega	Assistant Professor	K J Somaiya college of science and commerce

Foreword

Autonomy reflects efforts for excellence in academic performances, capability of self-governance and enhancement in the quality of education. In the year 2012, the UGC and University of Mumbai conferred the Autonomous Status to K J Somaiya College of Science and Commerce. Post this recognition and having several accolades to our credit, we made significant changes to our existing syllabi to reflect the changing business, industrial and social needs. A holistic education that provides opportunities to gain and share knowledge, experiment and develop beyond curriculum, is offered at our College.

Autonomous colleges carry a prestigious image for the students and the teachers and we have made a collaborative attempt to maintain a high level of quality in the standard of education that we impart.

Structured feedback obtained from the students, alumni and the experts from the industry and the changes suggested by them were duly incorporated in the syllabi. The Board of Studies constituted for each department meets to carry out in depth discussions about different aspects of the curriculum taking into cognizance the recent trends in the discipline.

The IQAC team has facilitated the conduct of a number of workshops and seminars to equip the faculty with the necessary skill set to frame the syllabi and competencies to deliver the same. Training was also provided to employ innovative evaluation methods pertaining to higher cognitive levels of revised Bloom's taxonomy. This

ensured the attainment of the learning outcomes enlisted in the syllabus. Audits are conducted to critically review the practices undertaken in teaching, learning and evaluation. Innovative learning methodologies such as project-based learning, experiential learning and flip- class learning practiced by a committed fleet of faculty, supported by several hands have been our unique outstanding propositions. All efforts have been made to nurture the academic ambitions as well as the skills in co-curricular activities of the most important stakeholder i. e. student.

With sincere gratitude, I acknowledge the constant support and guidance extended by Shri Samir Somaiya, President- Somaiya Vidyavihar, and all the esteemed members of the Governing board and Academic council of the College. I also would like to acknowledge the Heads of the Departments and all the faculty members for their meticulous approach, commitment and significant contribution towards this endeavor for academic excellence.

Dr. Pradnya Prabhu
Principal

Acknowledgement

At the outset, I would like to thank our Principal Dr. Pradnya Prabhu for her guidance and support during the curriculum restructuring process. I am also grateful to all the esteemed members of the Board of Studies, for their constructive suggestions and input for framing the syllabus.

Above all, I am deeply indebted to all the young and vibrant colleagues in the Department of Chemistry for the long and arduous work they have put in during the compiling of the restructured syllabus for MSc part 2 as per the N E P.

Dr. Bright O Philip
Chairperson
Board of Studies in Chemistry

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Preamble

The developments in Chemistry during the last few decades are phenomenal. The higher education has to inculcate in students the spirit of hard work and research aptitude to pursue further studies in the nationally/internationally reputed institutions as well as prepare them for a wider range of career opportunities in research institute, industry and commerce. On this background it was felt that a new M.Sc. a programme of Chemistry was needed, which will essentially be of our interdisciplinary nature. Keeping all this in mind, the curriculum under Learning Outcome-based Curriculum Framework (LOCF) is designed.

This Learning Outcome-based Curriculum Framework (LOCF) supports the fundamental principle of providing quality education in India. Our focus is to involve young minds to participate, contribute and add value at each stage in the field of their study. The introduction of Choice Based Credit System (CBCS) has maximised the benefits of the newly designed curriculum in multiple folds. The Board of Studies in Chemistry has restructured the curriculum for M.Sc. Chemistry so as to monitor, review and enhance educational provision which ensures to provide a firm foundation in every aspect of Chemistry and to develop theoretical, analytical, experimental, computational and reasoning skills of students. The Board of Studies acknowledges and appreciates the good effort put in by the faculty members of the Department of Chemistry to frame the syllabus for M.Sc. Programme in Chemistry in the institution which will be implemented for the admissions from 2023 onwards.

1. Introduction

Chemistry is the science of matter and its transformations. The main objective of this programme is to impart the key knowledge of chemical sciences and expertise to prepare students for careers in chemistry with high scientific depth and temperament and to prepare quality postgraduates for further research and development and entrepreneurship. **The eligibility criteria for enrolment in the M.Sc. in Chemistry programme is Bachelor's Degree with minimum 55% marks in Major/Honours in Chemistry, or 50% marks in Chemistry as well as in aggregate if not having Major/Honours in Chemistry.** The M.Sc. in organic chemistry programme comprises four Major courses and two electives/On Job Training/ Project work during each semester spread over two academic years. The total credit requirement to acquire the M.Sc. degree is **88 credits.** The framework helps to maintain the standard of chemistry programmes through periodic programme review within a broad framework of expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes.

Everything on Earth consists of chemicals made up of atoms, ions, and molecules. Understanding the elements in nature is essential to grasp their functions, significance, and applications. This foundational knowledge of chemistry enables us to explore and manipulate the substances around us, leading to advancements in technology, improved processes, and solutions to complex scientific and industrial challenges.

The basic knowledge of elements present in nature is essential to know its working, importance and applications. Chemistry is the study of science that deals with constituents of matter like atoms molecules, ions etc.; and its properties, structure, behaviour, and interactions among them. Since everything is made up of atoms and

molecules, we can see the chemistry all around us. Today, chemistry has grown into a very diverse field. There is a significant overlap between chemistry and other branches of science, for example, biochemistry (chemistry and biology), physical chemistry (chemistry and physics), medicinal chemistry (medicine and chemistry), chemical engineering (chemistry and engineering) etc.

M.Sc. in Organic Chemistry is a comprehensive program that equips students with in-depth knowledge and advanced skills in the field of organic chemistry. The curriculum is designed to cover a wide range of topics, from the fundamental mechanisms of organic reactions to the latest analytical techniques and research methodologies.

The curriculum for the M.Sc. in Organic Chemistry programme is based on the learning outcome based curriculum framework (LOCF). The syllabus contains Major as well as elective courses which are mostly Discipline specific. The courses are designed in such a way to cover the entire spectrum of chemical sciences from fundamentals (that will bring admitted students from various backgrounds to a common level) to most recent advancements in the field (that will make them ready to take up challenging assignments in the real world). The LOCF will certainly help teachers to envisage the outcome expected from the learners at the end of the programme. For students, it will be a guide which shows how this curriculum will help them acquire all the skills and knowledge which are essential in their personal and academic growth.

The program structure provides an opportunity to a student to choose any elective courses from the syllabus comprising different elective courses. The syllabus offers a flexibility of programme structure while ensuring that students get a strong foundation and gain in-depth knowledge in chemistry. The research-based project work in the curriculum ensures team building attitude within students and utilizes

every aspect of the team members in the success of any project. The project evaluation method is designed in such a way that it helps in creating a strong background for the research, skills to generate systematic reports and create effective presentation.

2. Learning Outcome based Curriculum Framework

The curriculum framework, curriculum goals, learning targets, and objectives are the main topics of LOCF. Additionally, the curriculum framework offers illustrations of efficient teaching, learning, and evaluation techniques. Since curriculum development is a cooperative, ongoing process of improvement, the LOCF advises regular reviews and revisions of the curriculum to better meet the ever-evolving needs of society, teachers, and students.

The framework explains how Major subject knowledge, specialization, choice-based learning, and other skill-enhancement courses are provided to students in order to ensure the development of an integrated personality and employability. In addition to specific learning course outcomes at the beginning of each course, the template defines expected outcomes for the program, such as Major competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, and leadership readiness. In the field of outcome-based curriculum design, the Learning Outcomes based Curriculum Framework (LOCF) for M.Sc. Chemistry will undoubtedly be an invaluable resource.

2.1 Nature and extent of M.Sc. Organic Chemistry

The cutting edge and fundamental subjects from Physical, Inorganic, Organic, and Analytical chemistry are all perfectly balanced in a Chemistry degree program. The nature of particular chemical branches affects the scope of individual topics. Courses on business skills in chemistry and food/cosmetic analysis are offered as part of the curriculum in an effort to increase the employability of postgraduate chemistry program graduates. The duration of the M.Sc. Organic Chemistry program is two years. Every year consists of two semesters. There are four semesters in all.

The M.Sc. Organic Chemistry program will use both lectures and practicals for teaching and learning. Powerpoint presentations, audio and video tools, and other teaching aids can be used as needed during formal lectures covering the curriculum. The RBPT approach will be used whenever feasible to improve the learner-centricity of the learning process. ICT-based teaching and learning resources will be used to make even the most boring subjects more engaging and pertinent.

2.2 Programme Education Objectives (PEOs)

The overall aims of master's degree programme in Organic chemistry are to:

1. Foster an intellectually stimulating environment for deep understanding in various chemistry branches.
2. Provide postgraduate students with tailored education through diverse elective courses.
3. Empower students with advanced analytical tools to address complex challenges in chemistry.
4. Equip students to apply advanced knowledge to theoretical and applied problems in specialised areas.
5. Instil a passion for continuous learning and professional development in postgraduate students.

6. Develop leadership skills and a strategic mindset while emphasizing ethical and responsible practices.

These PEOs for a postgraduate program aim to not only deepen the students' knowledge but also prepare them for leadership roles, advanced research, and a lifelong commitment to learning and ethical practices in the field of chemistry.

3. Graduate Attributes in Organic chemistry

Attributes expected from the Post graduates of M.Sc. Organic Chemistry Programme are:

GA 1: Cultivate Advanced Expertise: Demonstrate a mastery of advanced and specialized knowledge across diverse branches within chemistry, showcasing a deep understanding of intricate concepts and emerging trends in the field.

GA 2: Engage in Specialized Choice-Based Learning: Articulate a personalized and well-informed academic pathway by selecting and completing a range of elective courses, demonstrating a capacity to tailor education to align with specific research interests and career aspirations.

GA 3: Exhibit Enhanced Analytical Proficiency: Employ advanced analytical tools and methodologies to address complex challenges and issues in dynamic and specialized areas of chemistry, showcasing a high level of proficiency in critical thinking and problem-solving.

GA 4: Apply Advanced Knowledge and Skills: Demonstrate the application of advanced knowledge and skills in handling both theoretical and applied problems, showcasing preparedness for leadership roles in research, academia, or industry within specialized areas of chemistry.

GA 5: Promote Research and Innovation: Contribute to cutting-edge research initiatives, actively fostering an innovative environment and playing a role in the development of new methodologies, technologies, or theories within the field of chemistry.

GA 6: Facilitate Seamless Transition to Advanced Studies: Exhibit a strong foundational understanding of fundamental concepts, facilitating a seamless transition into advanced studies such as doctoral programs or specialized research opportunities within the realm of chemistry.

GA 7: Embrace Lifelong Learning: Demonstrate a commitment to continuous learning and professional development, staying informed about the latest advancements in chemistry and actively seeking opportunities for ongoing education throughout their professional careers.

GA 8: Foster Interdisciplinary Collaboration: Participate in interdisciplinary collaborations, engaging with experts from diverse fields to address complex challenges and broaden the impact of chemical research and applications beyond traditional boundaries.

GA 9: Develop Leadership Skills: Cultivate leadership skills and a strategic mindset, preparing for and actively seeking leadership roles in academia, research institutions, industry, or governmental organizations within the field of chemistry.

GA 10: Uphold Ethical and Responsible Practices: Demonstrate a commitment to ethical considerations and responsible practices in research and the application of chemical knowledge, instilling a sense of social and environmental responsibility in all professional endeavors.

4. Qualification descriptors

Upon successful completion of the programme, students receive M.Sc. degree in Organic Chemistry. This post graduate course of the department is expected to demonstrate the extensive theory knowledge of various concepts of chemistry and its application thus contributing in research, development, teaching, government and public sectors. The research project and laboratory training will flourish the students to connect between industry and academics wisely and precisely. This programme will establish a foundation for students to further pursue higher studies in chemistry. The list below provides a synoptic overview of possible employment areas after their completion of post graduation -

The list below provides a synoptic overview of possible career paths provided by an undergraduate training in Chemistry:

1. Academics
2. Research
3. Pharmaceutical company
4. Chemical Industry
5. Polymer Industry
6. Agrochemical Industry
7. Forensic science department
8. Oil and gas sectors
9. Cosmetic industry
10. Paints and dyes
11. Sustainable chemistry and Energy
12. Petrochemical Industry
13. Environmental monitoring and analysis
14. Packaging technology

Job Roles for M.Sc. Organic Chemistry graduate:

After graduation one can seek a professional career as:

1. Research
2. Lab chemist
3. R & D Chemist
4. Production officer
5. Quality control chemist
6. Academist
7. Environment analyst
8. Project fellow
9. Entrepreneur
10. Civil services
11. Competitive exams

Higher Education options for M.Sc. Organic chemistry graduate:

1. Ph.D. in Chemistry
2. M.Sc. in general chemistry/analytical chemistry/organic chemistry/physical chemistry/Drug chemistry/ Pharmaceutical chemistry/Environment chemistry/Polymer chemistry
3. PG Diploma in advance instrumental analysis/drug design/Intellectual Property rights/ Clinical research, etc
4. Courses in management
5. B.Ed

The learners who complete three years of full-time study of an undergraduate programme of study will be awarded a Bachelor's degree in chemistry.

5. Programme Learning Outcomes (PLOs)

After the successful completion of modules in different courses of M.Sc. Organic Chemistry, the learner will be able to:

PLO I: Illustrate fundamental concepts of physical, inorganic, organic, and analytical chemistry, to analyze complex chemical systems, predict reaction mechanisms, design innovative materials, and develop sophisticated analytical techniques to solve advanced scientific and industrial problems.

PLO II: Relate Cutting-edge Knowledge acquired in different fields of organic chemistry by mastering the fundamental principles of structure, bonding, and functional groups; demonstrating knowledge of reaction mechanisms; applying concepts of stereochemistry; and utilizing various spectroscopic methods to determine molecular structures.

PLO III: Develop problem-solving skills specific to organic chemistry, including the ability to propose mechanisms and predict the outcomes of organic reactions.

PLO IV: Acquire and demonstrate competency in laboratory techniques used in organic chemistry, such as synthesis, purification, and analysis of organic compounds.

PLO V: Apply good laboratory practices and safety principles in organic chemistry, to enhance experimental accuracy while fostering a proactive approach to minimize environmental impact and to promote sustainable practices in chemical research.

PLO VI: Justify the central role of chemistry in addressing societal challenges for lifelong learning to contribute to advanced technological innovations, solving global issues, and adapting to evolving scientific landscapes.

5.1 Course Mapping

Semester	PLO / Course		I	II	III	IV	V	VI
I	MJI		√		√		√	√
	MJII		√	√	√	√	√	
	MJIII		√	√		√	√	√
	MJIV		√		√		√	√
	DSE I DSE II	Any One	√	√	√		√	√
	RM		√		√	√	√	√
II	MJI		√	√	√			√
	MJII		√	√	√	√	√	
	MJIII		√	√		√	√	√
	MJIV		√	√	√		√	√
	DSE I DSE II	Any One	√	√			√	√
III	MJI		√	√	√			√
	MJII		√	√	√	√	√	
	MJIII		√	√		√	√	√
	MJIV		√	√	√	√	√	
	DSE I DSE II	Any two		√	√	√	√	√

	DSE III						
IV	MJI	√	√	√	√	√	
	MJII	√	√	√	√	√	
	MJIII	√	√		√	√	√
	MJIV	√	√	√	√	√	
	RIA	√	√		√	√	√

6. Structure of M.Sc. Organic chemistry programme

The programme consists of two years (two semesters per year). The syllabus is drafted such that all significant theoretical subjects are covered in the initial three semesters with an emphasis on on-the-job training and research project/ internship/ apprenticeship work in industry or certified laboratories.

Sem	Major	DSE	RM/OJT/ RIA	Total
1	14	4	RM 4	22
2	14	4	OJT 4	22
3	16	6		22
4	8	-	RIA 14	22

RM: Research Methodology Course

RIA: Research Project/ Internship/Apprenticeship

OJT: On Job Training.

• In semester I, the learner will have four major Major courses on General chemistry, one discipline specific elective and one common minor course on Research Methodology.

• In Semester II, the learner will have four major Major courses on Advanced chemistry, one discipline specific elective and will have to engage in an on-the-job training for 21 days.

• In Semester III the subject specialisation begins, the learner has four courses in **Chemistry** and two discipline specific elective courses

• In Semester IV the learner has four courses in **Chemistry,** and will have to complete one long Research Project and submit a dissertation at the end of the semester.

• Dissertation should be appreciable, original and of good quality. Assessment of dissertation will be based on an open viva for defence.

1. Major Major Courses (MJ):

a) A course which is required to be opted by a candidate as a major Major course. The course designed under this category aims to cover the basics that a student is expected to imbibe in that particular subject or discipline.

b) There are sixteen Major Major courses (MJ), four each, in semesters I II, III and IV

c) Each Major Major Courses is compulsory.

d) Each Major Major Course consists of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1.5 credit per practical of two hours per week per course in every semester.

e) The purpose of fixing major Major papers is to ensure that the institution follows a minimum common curriculum so as to adhere to common minimum standards with other universities/institutions.

2. Discipline Specific Elective (DSE):

a) A course is chosen by the candidate from the same stream as an elective out of the three courses offered. Elective course helps the student to gain a broader understanding of the specialization in the major discipline.

b) There is one DSE course each in semester I, II and two in semester III. The credits assigned are 2 credits for theory ie. 30 hours; 2 lectures of 1 hr each per week and 2 credits for practical of four hours per week in semester 1 and 2. In semester 3, there are 2 credits for theory per course and 1 credit each for the practical.

3. Research Methodology (RM)

a) This is a mandatory Minor that all post graduate students of science have to take.

b) Students are required to achieve understanding of the various nuances of research, how to formulate a research problem, plan the work and execute it effectively. Scientific writing and other skills relevant to research are taught here.

c) This course carries 4 credits (60 - hours in class teaching)

4. On Job Training (OJT)

a) On Job training or Internships are introduced as per the guidelines of the National Education Policy (NEP) 2020, which emphasizes the importance of research and internships in postgraduate education. The internships will be mandatory for students in three-year and four-year degree programs, with a duration of 60 to 120 hours.

b) This seeks to equip students with the ability to gain relevant soft skills such as teamwork, problem-solving, work ethics, adaptability, communication, and time management.

c) This training carries 4 credits. 1 credit corresponds to 30 hours of engagement in a semester.

5. Internship (INT):

a) One of the fundamental principles guiding the development of our education system as per NEP 2020 is the fostering of 'outstanding research as a Majorquisite for outstanding education and development'. with this perspective Research project / Dissertation is a mandatory component of the masters program

b) Here the learner is assigned a research problem related to their field of specialization either within the department or at a premier institute of the country. The learner has to complete their research and present their dissertation at the end of the period.

c) Internship is introduced in semester IV of M.Sc course, having 14 credits. 1 credit of internship corresponds to 30 hours of engagement in a semester.

6.1 Course Content

Sr. No	Semester	Course number	Course Code	Course title
Major Course (CC)				
1	I	MJI	23PSICHMJICTM	Chemical Thermodynamics
2		MJII	23PSICHMJ2IRO	Inorganic Reaction mechanisms and Organometallic Chemistry
3		MJIII	23PSICHMJ3SOR	Stereochemistry and Oxidation-Reduction
4		MJIV	23PSICHMJ4QCS	Quality control and Spectroscopic techniques
5		MJP	23PSICHMJPI 23PSICHMJP2	Practicals based on each Major Course- [MJI+MJ4=PI, MJ2+MJ3=P2]
6		DSE	23PSICHDSEBTC	Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques
7			23PSICHDSEPBS	Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis
8		DSEP	23PSICHDSEBTCP/ 23PSICHDSEPBSP	Practical based on the DSE course
9		RM	23PSICHRM	Research Methodology

10	II	MJI	23PS2CHMJIQCK	Quantum chemistry and Chemical Kinetics
11		MJII	23PS2CHMJ2GIC	Group theory and Inorganic cluster compounds
12		MJIII	23PS2CHMJ3OSS	Organic synthesis and Spectroscopy
13		MJIV	23PS2CHMJ4SST	Separation and spectroscopic techniques
14		MJP	23PS2CHMJPI 23PS2CHMJP2	Practicals based on each Major Course- [MJI+MJ4=PI, MJ2+MJ3=P2]
15		DSE	23PS2CHDSECCE	Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid
16			23PS2CHDSENRE	Nanochemistry and Renewable Energy Resources
17		DSE P	23PS2CHDSECCEP/ 23PS2CHDSENREP	Practical based on each DSE course
18		OJT	23PSICHOJT	On Job Training
19	III	MJI	24PS3OCHMJIPHS	Photochemistry and Stereochemistry
20		MJII	24PS3OCHMJ2AHC	Aromaticity and Heterocyclic Chemistry

21		MJIII	24PS3OCHMJ3NDS	Name reactions and designing organic synthesis
22		MJIV	24PS3OCHMJ4CNP	Chemistry of Natural products
23		MJP	24PS3OCHMJP1 24PS3OCHMJP2	Practicals based on each Major Course- [MJ1+MJ2=P1, MJ3+MJ4=P2]
24		DSE I	24PS3OCHDSEPRP	Pericyclic Chemistry and reaction pathway
25		DSE II	24PS3OCHDSEIPR	Intellectual property rights
26		DSE III	24PS3OCHDSECCC	Carbohydrates and Chiron Chemistry
27		DSE P	24PS3OCHDSEPRPP/ 24PS3OCHDSEIPRP/ 24PS3OCHDSECCCP	Practicals based on any two DSE courses
28	IV	MJI	24PS4OCHMJITOC2	Theoretical Organic Chemistry 2
29		MJII	24PS4OCHMJ2EOS	Enamines and Ylides and Metals, Non-metals in organic synthesis
30		MJIII	24PS4OCHMJ3DDB	Drug designing and biomolecules
31		MJIV	24PS4OCHMJ4AOS	Advanced organic spectroscopy
32		RP/INT/A	24PS4OCHRIA	Research Project/Internship/ Apprenticeship

6.2 Credit distribution for M.Sc. Organic Chemistry

Semester	Course number	Course title	Credits		
			Theory	Practical	Total
I	MJI	Chemical Thermodynamics	2	1.5	3.5
	MJII	Inorganic Reaction mechanisms and Organometallic Chemistry	2	1.5	3.5
	MJIII	Stereochemistry and Oxidation-Reduction	2	1.5	3.5
	MJIV	Quality control and Spectroscopic techniques	2	1.5	3.5
	DSE	Student will choose any one DSE - Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques/ Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis	2	2	4
	RM	Research Methodology	4	-	4
	Total				**22**
II	MJI	Quantum chemistry and Chemical Kinetics	2	1.5	3.5
	MJII	Group theory and Inorganic cluster compounds	2	1.5	3.5
	MJIII	Organic synthesis and Spectroscopy	2	1.5	3.5

	MJIV	Separation and spectroscopic techniques	2	1.5	3.5
	DSE	Student will choose any one DSE- Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid/ Nanochemistry and Renewable Energy Resources	2	2	4
	OJT	On Job Training	-	4	4
	Total				**22**
III	MJI	Photochemistry and Stereochemistry	2	2	4
	MJII	Aromaticity and Heterocyclic Chemistry	2	2	4
	MJIII	Name reactions and designing organic synthesis	2	2	4
	MJIV	Chemistry of Natural products	2	2	4
	DSE I Any two	Pericyclic Chemistry and reaction pathway	4	2	6
	DSE II	Intellectual property rights			
	DSE III	Carbohydrates and Chiron Chemistry			
	Total				**22**
IV	MJI	Theoretical Organic Chemistry	2	-	2

	MJII	Enamines and Ylides and Metals, Non-metals in organic synthesis	2	-	2
	MJIII	Drug designing and biomolecules	2	-	2
	MJIV	Advanced organic spectroscopy	2	-	2
	RIA	Research Project/Internship/ Apprenticeship	14	-	14
	Total				**22**

6.3 Semester Schedule

Semester	Major Major Courses (MJ)	DSE [Any one per semester]	RM/OJT	CC
I	Chemical Thermodynamics	Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques	RM	-
	Inorganic Reaction mechanisms and Organometallic Chemistry	Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis		
	Stereochemistry and Oxidation-Reduction			
	Quality control and Spectroscopic techniques			
II	Quantum chemistry and Chemical Kinetics	Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid	OJT	-
	Group theory and Inorganic cluster compounds	Nanochemistry and Renewable Energy Resources		
	Organic synthesis and Spectroscopy			
	Separation and spectroscopic techniques			

III	Photochemistry and Stereochemistry	Pericyclic Chemistry and reaction pathway		
	Aromaticity and Heterocyclic Chemistry	Intellectual property rights		
	Name reactions and designing organic synthesis	Carbohydrates and Chiron Chemistry		
	Chemistry of Natural products			
IV	Theoretical Organic Chemistry	_	-	RIA
	Enamines and Ylides and Metals, Non-metals in organic synthesis			
	Drug designing and biomolecules			
	Advanced organic spectroscopy			

6.4 Course Learning Objectives

The two year postgraduate Organic Chemistry programme is designed to familiarize students with in-depth knowledge of Chemistry. The objective of structured syllabus in Chemistry is to make the concepts and basics of Chemistry clear and interesting to students and also to ensure the development of vertical growth in the subject. The idea behind this is to enable students to develop analytical skills and critical thinking. It is our attempt that students achieve this objective through systematic reading and class lectures and through feedback on their written work-assignments, project/research papers, presentations, discussions, debates, etc. our intention is to enable students to formulate cogent arguments, presenting the necessary evidence to establish these, based on a training in Chemistry.

7. Detailed M.Sc. Organic Chemistry Syllabus

M.Sc. Organic Syllabus with effect from the Academic year 2023-2024

Syllabus - M.Sc. Organic Chemistry

Course No.	Course Title	Course Code	Credit	Hr. Periods in Hrs. (60 min)	Module	Lectures per module (60 minutes)	Examination		
							Internal Marks	External Marks	Total Marks
SEMESTER I									
Major Courses THEORY									
I	Chemical Thermodynamics	23PSICHMJICTM	2	30	2	15	20	30	50
II	Inorganic Reaction mechanisms and Organometallic Chemistry	23PSICHMJ2IRO	2	30	2	15	20	30	50
III	Stereochemistry and Oxidation-Reduction	23PSICHMJ3SOR	2	30	2	15	20	30	50
IV	Quality control and Spectroscopic techniques	23PSICHMJ4QCS	2	30	2	15	20	30	50
Major courses PRACTICAL									

	Practicals based on each Major Course- [MJ1+MJ4=P1, MJ2+MJ3=P2]	23PSICHMJP1 23PSICHMJP11	6	60			CIE		50
Discipline Specific Elective DSE [Any one]									
DSE Any one	Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques	23PSICHDSEBTC	2	30	2	15	20	30	50
	Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis	23PSICHDSEPBS							
DSE Practical									
DSEP	Practical based on chosen DSE course	23PS2CHDSEBTCP/ 23PS2CHDSEPBSP	2	30				CIE	50
Research Methodology									
RM	Research Methodology	23PSICHRM	4	60				CIE	100

SEMESTER II									
Major courses THEORY									
I	Quantum chemistry and Chemical Kinetics	23PS2CHMJ1QCK	2	30	2	15	20	30	50
II	Group theory and Inorganic cluster compounds	23PS2CHMJ2GIC	2	30	2	15	20	30	50
III	Organic synthesis and Spectroscopy	23PS2CHMJ3OSS	2	30	2	15	20	30	50
IV	Separation and spectroscopic techniques	23PS2CHMJ4SST	2	30	2	15	20	30	50
Major courses PRACTICAL									
	Practicals based on each Major Course- [MJ1+MJ4=P1, MJ2+MJ3=P2]	23PS2CHMJP1 23PS2CHMJP2	6	60				CIE	50
Discipline Specific Elective DSE [Any one]									
DSE Any one	Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid	23PS2CHDSECCE	2	30	2	15	20	30	50

	Nanochemistry and Renewable Energy Resources	23PS2CHDSENRE							
DSE Practical [any one]									
DSEP	Practical based on chosen DSE course	23PS2CHDSECCEP/ 23PS2CHDSENREP	2	30				CIE	50
On Job Training									
OJT		23PS1CHOJT							

M. Sc. CHEMISTRY SEMESTER I

Major Course- I

COURSE TITLE: Chemical Thermodynamics

COURSE CODE: 23PSICHMJICTM

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Identify state functions, derive thermodynamic and maxwell relations using differential equations 2. Discuss the applications of the first ,second and third Law of thermodynamics . 3. Explain the concept of fugacity and its significance in describing the behavior of real gases, including its relation to pressure 4. Describe the equilibrium constant for real gases in terms of fugacity and understand how it differs from the ideal gas equation.

Module 1	Thermodynamics-I	[15L]

Learning Objectives:

The module is intended to-

- Explain the properties of state functions, Thermodynamic quantities and Maxwell relations
- Discuss the applications of thermodynamic concepts like Joule Thomson coefficient and statistical treatment of Entropy.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

- Illustrate state function, derive Maxwell relations and interrelated properties of thermodynamic quantities using differential equations.

• Develop the thermodynamic concepts like inversion temperature , Joule-Thomson Coefficient and statistical treatment of Entropy		
Module 1	**Thermodynamics-I**	**[15L]**
1.1	State function, Exact and inexact differentials, Cyclic rule, Coefficient of thermal expansion (α) and Compressibility Coefficient (β) and relationship between α and β, Integrating factor. Maxwell equations, Maxwell thermodynamic square. Enthalpy as a function of Temperature and pressure for ideal and real gases.	[5L]
1.2	Joule-Thomson coefficient, Joule-Thomson coefficient in terms of van der Waals constants, inversion temperature, Free Expansion of a gas. Relationship between C_p and C_v. Mathematical treatment of Entropy concept, Entropy as state function, Thermodynamic equation of state.	[5L]
1.3	Entropy changes for a system, surrounding and phase transition, Third law of thermodynamics, Evaluation of absolute entropies, determination of absolute entropies in terms of heat capacity data, standard molar entropies and their dependence on molecular mass and molecular structure. Residual entropy.	[5L]
Module 2	**Thermodynamics-II**	**[15L]**
Learning Objectives: This module is intended to: 1. Impart knowledge about fugacity of real gases and its various methods of determination.		

2. Understand the significance of fugacity in describing the thermodynamic properties of real gases. 3. Formulate the methods to determine the partial molar properties.		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Explain the concept of fugacity of real gases, and its significance in describing the thermodynamic properties of real gases, including its relation to pressure and temperature. 2. Describe the thermodynamic functions of mixing, excess functions and determination of partial molar properties.		
Module 2	**Thermodynamics-II**	**[15L]**
2.1	Fugacity, relation between fugacity and pressure, determination of fugacity of a real gas, variation of fugacity with temperature and pressure. Equilibrium constant for real gases in terms of fugacity. Activity, dependence of activity on temperature and pressure.	[6L]
2.2	Thermodynamic functions of mixing: Gibbs energy of mixing, entropy and enthalpy of mixing. Excess functions of non-ideal solutions: excess thermodynamic functions of chemical potential, Gibb's free energy, entropy, enthalpy and volume.	[6L]
2.3	Partial molar quantities: calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation.	[3L]

References:

- R. P. Rastogi & R. R. Mishra, An Introduction to Chemical Thermodynamics, 6th Revised Edition.,Vikas Publishing House PVT Ltd.
- Donald A. McQuarrie and John D. Simon, Physical Chemistry-A Molecular Approach, Viva Books PVT Ltd.
- Peter Atkins and Julio de Paula, Physical Chemistry, 10th Edition, Oxford University Press, Thomson Press (India) Ltd.
- K. L. Kapoor, A TextBook of Physical Chemistry-Thermodynamics and Chemical equilibrium, 4th Edn., Vol.2, Macmillan Publishers India Ltd
- J. Gareth Morris, A Biologist's Physical Chemistry, 2nd edition, ELBS & Edward Arnold Pub. Ltd.

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Chemical Thermodynamics

COURSE CODE: 23PSICHMJICTM [CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	5	15	-	-	-	20
II	-	5	5	-	10	-	20
Total marks per objective		10	20		10	-	40
% Weightage		25	50		25	-	100

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- II (THEORY)

COURSE TITLE: Inorganic Reaction mechanisms and Organometallic Chemistry

COURSE CODE: 23PSICHMJ2IRO

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Identify, analyze and describe the reactivity of transition metal complexes, distinguishing between inert and labile complexes, theories underlying electron transfer reactions. 2. Evaluate the synthesis, properties, structure, and bonding of various organometallic compounds and explore their various applications.

Module 1	Inorganic Reaction Mechanisms	[15L]

Learning Objectives:

The module is intended to

1. Introduce the various mechanisms involved in electron transfer and substitution reactions in inorganic complexes.
2. Elaborate the theories of trans effect and its utility in preparation of its geometrical isomers.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Illustrate the mechanism of inorganic reactions.
2. Predict the products of various electron transfer reactions.

1.1	Introduction, Reactivity of transition metal complexes: Inert and labile complexes, SN1 and SN2 reaction mechanism, Types of intermediate/activated complex formed during SN1 and SN2 mechanism, Rate of reactions.	[3L]
1.2	Mechanism and factors affecting ligand substitution reactions of: (a) Octahedral complexes without breaking of metal-ligand bond (b) Square planar complexes – trans-effect, its theories and applications & (c) Tetrahedral complexes.	[6L]
1.3	Redox reactions: Mechanism of electron transfer reactions - (a) Electron and atom transfer reactions (b) Inner and outer sphere mechanisms (c) Marcus theory (Numericals expected) & (d) Complementary and non-complementary reactions.	[4L]
1.4	Isomerization and racemization reactions	[2L]

Module 2	Organometallic Chemistry	[15L]
Learning Objectives: This module is intended to: 1. Discuss synthesis, structure, and bonding of organometallic compounds. 2. Explain the role of organometallic compounds in various catalytic reactions and mechanistic details.		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Interpret the bonding prospect involved in various organometallic compounds. 2. Ilustrate various organometallic reactions involved in catalytic cycle, turnover number and turnover frequency.		
2.1	Organometallic compounds of transition metals: Synthesis, properties, Structure and bonding of the following organometallic compounds: (a) Alkyl and Aryl derivatives (b) Carbenes and Carbynes (Fischer and Tropsch) (c) Alkyne complexes [diphenylacetylene platinum (O)] (d) Arene complexes - sandwich [dibenzene chromium (O)] and half sandwich (CpMn(CO)3, CpNi(NO).	[8L]

2.2	Organometallics as Catalysts in Organic Reaction, 16 and 18 electron rule: (a) Hydrogenation (b) Asymmetric hydrogenation (c) hydroamination (d) Monsanto process (e) hydroformylation	[5L]
2.3	Organometallics in medicine, agriculture, and their biological and environmental aspects.	[2L]

References:

1. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, Delhi, 1993.
2. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions 2nd ed., Wiley, New York, 1967.
3. D. Benson, Mechanisms of Inorganic Reactions in solution, McGraw – Hill, New York, 1968.
4. J. O. Edwards, Inorganic Reaction Mechanisms, Benjamin, New York, 1974.
5. Geeta Tewari, Inorganic Chemistry II, S. Chand Publications, 2018.
6. R. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd ed., New Age International Pvt. Ltd., 2000.
7. Gary O. Spessard and Gary L. Miessler, Organometallic Chemistry, Prentice Hall, 1977.
8. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5th ed., Wiley Interscience, 2009.
9. K. F. Purcell and J. C. Klotz, Inorganic Chemistry, Saunders, Hongkong, 1977.

10. B. Douglas, D. H. McDaniel and J. J. Alexander. Concepts and Models of Inorganic Chemistry, 2nd Ed., John Wiley & Sons, 1983.
11. James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 2006
12. Gopalan and Ramalingam, Concise coordination chemistry 2012.
13. Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Inorganic Reaction mechanisms and Organometallic Chemistry

COURSE CODE: 23PSICHMJ2IRO

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I		13	5			2	20
II	3	4	5	2	3	3	20
Total marks per objective	3	17	10	2	3	5	40
% Weightage	7.5	42.5	25	5	7.5	12.5	100

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- III (THEORY)

COURSE TITLE: Stereochemistry and Oxidation-Reduction

COURSE CODE: 23PSICHMJ3SOR

[CREDITS - 02]

Course Learning Objectives
After the successful completion of the Course, the learner will be able to: 1. Describe the stereochemistry of compounds with central, axial and planar chemistry. 2. Design the synthesis of organic compounds using specific reagents for oxidation reduction reactions.

Module 1	Stereochemistry-I	[15L]
Learning Objectives: Learners will be able to understand the fundamental concepts of stereochemistry		
Learning Outcomes: After the successful completion of the module, the learner will be able to predict the R-S configuration of compounds with central, axial and planar chirality.		

1.1	Symmetry operations: Rotation, reflection, inversion, rotation-reflection. Identification of the different axes and planes of symmetry. Molecules with tri and tetra coordinate chiral centres: Compounds with carbon, silicon, nitrogen, phosphorous and Sulphur chiral centres and their relative configurational stabilities	[4L]
1.2	Molecules with two or more chiral centres: Configurational nomenclature. Constitutionally unsymmetrical molecules: Erythro-threo and syn-anti systems. Constitutionally symmetrical molecules with odd and even number of chiral centres: enantiomeric and meso forms, concept of stereogenic, chirotopic and pseudo asymmetric centres.	[3L]
1.3	Axial and planar chirality: Principles of axial and planar chirality. Stereo 4L chemical features and configurational descriptors (R, S) for the following classes of compounds: Allenes, Alkylidene cycloalkanes, Spiranes, Biaryls (including BINOLs and BINAPs), Ansa compounds and Cyclophanes.	[4L]
1.4	Prochirality: Homotopic, heterotopic and diastereotopic ligands and faces. Identification using substitution and symmetry criteria. Nomenclature of stereo heterotopic ligands and faces. Symbols for stereo heterotopic ligands in molecules with one or more prochiral centres, pro-pseudo asymmetric centre, chiral and prochiral centre; prochiral axis and prochiral plane. Symbols for enantiotopic and diastereotopic faces.	[4L]

Module 2	Oxidation - Reduction	[15L]
Learning Objectives: Learners will be able to elaborate the mechanism and applications of specific reagents for oxidation-reduction reactions in organic synthesis.		
Learning Outcomes: Learners will be able to Illustrate the use of specific reagents for oxidation-reduction reactions in organic synthesis.		
2.1	Oxidation: General mechanism, selectivity, stereochemistry and important applications of the following: (a) Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt/Pd/Ni) and organic reagents (Chloranil, DDQ). (b) Dehydrogenation/oxidation of alcohols to aldehydes and ketones: chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin's reagent), PCC (Majory's reagent) and PDC, hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation) and Oppenauer oxidation. (c) Oxidation involving C-C bonds cleavage: Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$.	[8L]

	(d) Oxidation involving replacement of hydrogen by oxygen: Oxidation of allylic CH_2 to CO by SeO_2, Oxidation of aryl methane by CrO_2Cl_2 (Etard oxidation).	
2.2	Reduction: General mechanism, selectivity, stereochemistry and important applications of the following reducing: (a) Reduction of CO to CH_2 in aldehydes and ketones – Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification. Ra-Ni desulfurization of Thioketal (Mozingo reduction) (b) Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, $Na(OAc)_3BH$, Aluminium reagents ($LiAlH_4$, DIBALH, Red Al, L and K selectrides), MPV reduction, NH_2NH_2 (diimide reduction (c) Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	[7L]

References:

1. D. Nasipuri, Stereochemistry of Carbon Compounds: Principles and Applications, 3rd Edition, New Age International Ltd.
2. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley- India.
3. P. S. Kalsi, Stereochemistry, 4th edition, New Age International Ltd.
4. M. J. T. Robinson, Organic Stereochemistry, Oxford University Press, New Delhi, India edition, 2005.

5. Jonathan Clayden, Nick Greeves and Stuart Warren Organic Chemistry (2nd Edition).
6. Seyan Ege, Organic Chemistry: Structure and Reactivity, 5th Edition.
7. Ratan Kumar Kar, Redox and Reagents in Organic Chemistry by (Volume I) NCBA Publication.
8. S.N Sanyal, Reactions, Rearrangements and Reagents.
9. Michael H Nantz, W. W. Freeman and Company, Modern Organic Synthesis, 1st Edition.

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Stereochemistry and Oxidation-Reduction
COURSE CODE: 23PSICHMJ3SOR

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	-	-	2	18	-	20
II	-	-	2	8	10	-	20
Total marks per objective	-	-	2	10	28	-	40
% Weightage	-	-	5	25	70	-	100

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- IV (THEORY)

COURSE TITLE: Quality control and Spectroscopic techniques

COURSE CODE: 23PSICHMJ4QCS

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Classify analytical methods and explain sensitivity, detection limit, dynamic range in analytical measurements and instruments used in chemical analysis. 2. Explain the principles, instrumentation and applications of IR and UV-Visible spectroscopy techniques.

Module 1	Introduction to Analytical Chemistry and Quality	[15L]

Learning Objectives:

The module is intended to

1. Discuss sensitivity, detection limit, and dynamic range in analytical measurements.
2. Describe various analytical methods and instrumentation used in chemical analysis

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Describe various analytical methods and instruments used in chemical analysis.
2. Explain sensitivity, detection limit, and dynamic range in analytical measurements

1.1	Recapitulation: Classification of Analytical methods, An overview of analytical methods, Types of instrumental methods Instruments for analysis, data domains, electric and non-electric domains, detectors, transducers, sensors, sensitivity, detection limit and dynamic range.	[4L]
1.2	Performance criteria of the method: calibration curve, standard addition and internal standard methods. selection of analytical method, performance characteristics of instruments, figures of merit	[6L]
1.3	Quality in analytical chemistry: quality systems in chemical laboratories, cost and benefits of a quality system, types of quality standards for laboratories Total quality management, quality audits and quality reviews, responsibility of laboratory staff for quality	[5L]

Module 2	Spectroscopic Technique I	[15L]
Learning Objectives: This module is intended to explain the principles, instrumentation and applications of IR and UV-Visible spectroscopy techniques.		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Discuss experimental setup and working of IR and UV-VIS spectrometers. 2. Illustrate important applications of IR and UV-VIS spectroscopy.		
2.1	IR Spectroscopy: Introduction, basic principle, types of molecular vibrations, vibrational modes, vibrational coupling and applications of IR regions. Dispersive and non-dispersive IR: Instrumentation in detail, working and its application, FT-IR: Principle instrumentation and working, Qualitative and quantitative application. (Numerical is expected)	[7L]
2.2	UV-Visible Absorption Spectroscopy: Introduction, basic principle, absorbing species, Auxochrome and chromophore, Aromatic systems, solvent effect. Application of UV-VIS spectroscopy: Derivative, Simultaneous and dual wavelength spectrometry: principle, instrumentation and working, application (Numerical is expected)	[8L]

References:

- Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987)
- Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)
- Fundamentals of Analytical Chemistry, D.A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
- Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Edition (1998)
- Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N. Y 1997
- Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Quality control and Spectroscopic techniques

COURSE CODE: 23PSICHMJ4QCS

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5		-	20
II	5	5	5	5		-	20
Total marks per objective	10	10	10	10		-	40
% Weightage	25	25	25	25		-	100

M. Sc. CHEMISTRY SEMESTER I

Course Title: Practical based on MJ1 and MJ4

COURSE CODE: 23PSICHMJP1 [CREDITS – 1.5]

Physical Chemistry - Course Learning Outcomes	
After the successful completion of the Course, the learner will be able to get hands-on experience in instrumental and theoretical concepts in thermodynamics.	
Learning Objectives: The module is intended to give hands-on experience in instrumental and theoretical concepts in thermodynamics.	
Learning Outcomes: After the successful completion of the module, the learner will be able to perform experiments to analyse the data and relate it to the theoretical concepts.	
Instrumental Experiments	
1	To determine the formula of silver – ammonia complex by potentiometric method
2	To determine Hammett constant of m- and p- amino / nitro benzoic acid by pH measurement
3	To verify Ostwald's dilution law and determine the dissociation constant of a weak monobasic acid conductometrically
4	To estimate the concentration of NH_4Cl salt with NaOH solution conductometrically

5	To determine the ionization constant of bromophenol blue
6	To determine pKa values of phosphoric acid by titration with sodium hydroxide using pH meter
	Non - instrumental Experiments
7	To study the three component system: Water – Acetic acid – Chloroform
8	To determine the heat of solution of benzoic acid / salicylic acid by solubility measurements
9	To study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and to determine the solubility product of $Ca(OH)_2$ at room temperature
10	To determine the chain linkage in poly vinyl alcohol from viscosity measurement

References

1. Vogel, Practical Organic Chemistry, 5th edition.
2. H. Middleton, Systematic Qualitative Organic Analysis.

Analytical Chemistry-Course Learning Outcomes

After the successful completion of the Course, the learner will be able to:

1. Explain the principles and applications of classical methods, experimental design, and data analysis.
2. Develop methods for tracing and measuring new substances, such as metals, non-metals, etc.
3. Collaborative teamwork to solve scientific problems
4. Design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

Learning Objectives:

The module is intended to

1. Describe various classical analytical methods used in chemical analysis.
2. Illustrate the use of classical separation techniques like solvent extraction, column chromatography, kinetic masking, etc.

Experiments	
1	Determination of amount of Cr (III) and Fe (III) individually in a mixture of two by Complexometric titration
2	Solvent Extraction: (1) Fe (III) & Mg (II) OR (2) Fe (III) & Ni (II)
3	Water analysis: Hardness, alkalinity, salinity, acidity
4	Anion exchange chromatography: (1) Ni (II) & Zn (II) OR (2) Co(II) & Ni(II)
5	Determination of Iodine value and Acid value of given oil sample
6	TLC and Column chromatography: separation of a mixture of ortho and para nitro-anilines
7	To carry out assay of the sodium chloride injection by Volhard's method OR To carry out assay of a given sample of saline by Mohr's method
8	To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin
9	To determine the number of nitro groups in the given compound using $TiCl_3$

References

- Inorganic quantitative analysis by Vogel sixth edition.
- Pharmacopoeia of India 2022, Eight edition
- Biochemical methods, Sadashivam and Manichem, New age international publication
- General Chemistry experiments by Elias, Universities Press

M. Sc. (CHEMISTRY) SEMESTER I

COURSE TITLE: Practical based on MJ2 and MJ3

COURSE CODE: 23PSICHMJP2

[CREDITS – 1.5]

Inorganic Chemistry-Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Prepare solutions of various of molarity, normality and ppm level. 2. Perform potentiometric, conductometric and spectrophotometric titrations to find the equivalence point. 3. Compare instrumental titrations over the conventional titration methods.
Learning Objectives: The module is intended to 1. Enable learners to prepare solutions of different concentration and operate instruments like potentiometer, conductometer and spectrophotometer/colorimeter. 2. Depict graphically their observations and determine the titration's equivalence point.

Instrumental methods of analysis:	
1	Conductometry: I. Estimation of chloride in NaCl/KCl using silver nitrate. II. Estimation of Boric acid using ammonium hydroxide.
2	Potentiometry: I. Estimation of Cu^{2+} using sodium thiosulphate. II. Estimation of Fe^{2+} using ceric ammonium sulphate.
3	Estimation of Ti and V using hydrogen peroxide
4	Spectrophotometer titration of Cu^{2+} against EDTA
5	Determination of formation constant by Job's variation method for Fe^{3+} - SCN^- system.

References

1. Vogel's Textbook of Chemical Analysis, 5th edition.
2. Advanced Practical Inorganic Chemistry, Gurudeep Raj, GOEL publishing House.

Organic Chemistry -Course Learning Outcomes		
After the successful completion of the Course, the learner will be able to: 1. Identify the type of the component in the binary mixture 2. Determine the physical constant of both components.		
Learning Objectives: Learners will be able to understand the basic separation, purification and characterization techniques in organic chemistry.		
Chemical separation of binary mixtures:		
1	Solid-Solid mixture (including water soluble component)	
2	Solid-liquid mixtures	

References

- I. Vogel, Practical Organic Chemistry, 5th edition.
- H. Middleton, Systematic Qualitative Organic Analysis.

M. Sc. (CHEMISTRY) SEMESTER I

Discipline specific Electives- I (Theory)

COURSE TITLE: Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques

COURSE CODE: 23PSICHDSEBTC

[CREDITS – 2]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Explore different structures of AB, AB_2, AB_3, A_2B_3, ABO_3, AB_2O_4 types and understand the role of metal ions in biological systems. 2. Discuss principles, instruments and applications of HPLC, GC and thermoanalytical methods.

Module 1	Bioinorganic and Solid State Chemistry	15L

Learning Objectives:

The module is intended to

1. Elaborate role of metal ions in biological systems.
2. Explain the structure of solid state compounds.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Appreciate the role of metal ions in biological systems.

	2. Describe structure and bonding in different types solid state compounds.	
1.1	Bioinorganic Chemistry Introduction, Role of metal ions in biological systems. Toxic metal ions and their detoxification, chelation therapy/chelating agents in medicine. Recent advances in cancer chemotherapy using chelates. Iron in Ferritin, Transferrin, Fe-S clusters, Porphyrin based systems.	[7L]
1.2	Solid State Chemistry Structures of Compounds of the type: (a) AB [PbO and CuO] (b) AB_2 type [β-cristobalite, CaC_2 and Cs_2O] (c) AB_3 (ReO_3, Li_3N), A_2B_3 type (Cr_2O_3 and Bi_2O_3), ABO_3 relation between ReO_3 and perovskite $BaTiO_3$ and its polymorphic forms, AB_2O_4 type, normal, inverse, and random spinel structures.	[8L]
Module 2:	**Separation and Thermoanalytical Techniques**	**15 L**
Learning Objectives: The module is intended to 1. Discuss instruments and components used in HPLC and GC. 2. Explain different thermoanalytical methods.		

Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Do sample analysis using HPLC and GC. 2. Interpret the thermoanalytical data for identification of compounds.		
2.1	HPLC & GC Technique Instruments for HPLC: Mobile phase reservoirs and solvent treatment system, pumping systems, sample injection systems, LC Columns, types of column packing, detectors: Absorbance detector, Refractive Index detector, column efficiency in LC, applications. Instruments for GC: Carrier gas system, sample injection systems, column oven, temperature programming, GC Column, stationary phase, detectors (coulometric, thermionic ionization detectors), applications.	8L
2.2	Thermoanalytical Techniques Introduction, Principle, instrumentation and applications of thermal methods – 1. Thermogravimetric analysis 2. Differential Thermal analysis 3. Differential Scanning Calorimetry	7L

References

Bioinorganic Chemistry

- Bertini, H.B. Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998.
- R. W. Hay, Bioinorganic Chemistry, Ellis Harwood, England, 1984.
- J. A. Cowan, Inorganic Biochemistry-An introduction, VCH Publication, 1993.
- S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Publications, Mill Valley, Caligronic, 1994.
- Robert Crichton, Biological inorganic Chemistry: A new introduction to molecular structures and functions, 3rd edition,. Academic press.

Solid State Chemistry

- R. West, Solid State Chemistry and Its Applications, John Wiley & Sons, New York, 1987.
- L. V. Azaroff, Introduction to solids, Tata McGraw Hill Book Co., New Delhi, 1977.
- H. V. Keer, Principles of Solid State, Wiley Eastern Ltd., 1993.
- N. R. Rao and G. Gopalkrishnan, New Directions in solid state chemistry, 2nd Ed.,Cambridge University Press, (1997).

HPLC, GC and Thermoanalytical methods

- Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987)
- Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)

- Fundamentals of Analytical Chemistry, D.A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
- Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Edition (1998)
- Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N. Y 1997
- Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Discipline Specific Elective Course- I

COURSE TITLE: Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques

COURSE CODE: 23PSICHDSEBTC [CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	15	-	3	2	-	20
II	-	6	2	8	2	2	20
Total marks per objective	-	21	2	11	4	2	40
% Weightage	-	52.5	5	27.5	10	5	100

M. Sc. (CHEMISTRY) SEMESTER I

DISCIPLINE SPECIFIC ELECTIVE PRACTICAL

COURSE TITLE: Bioinorganic Solid state and Thermal Analytical Chromatographic Techniques

COURSE CODE: 23PSICHDSEBTCP

[CREDITS – 2]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Analyze the food and drug samples for their percentage purity. 2. Quantitatively analyze ore and alloys. 3. Analyse sample using HPLC and GC. 4. Interpret the thermoanalytical data for identification of compounds.
Learning Objectives: The module is intended to 1. Make the learner prepare solutions of different concentrations. 2. Equip the learner to explore various steps/techniques in analysis of food samples, ore and alloys.
Learning Outcomes: After completion of the course, students shall able to 1. Analyze the food and drug samples for their percentage purity 2. Quantitatively analyze ore and alloys. 3. Do sample analysis using HPLC and GC.

	4. Interpret the thermoanalytical data for identification of compounds
Solid state Chemistry	
1.1	Limestone Ore: 1. Loss on ignition, Ca by EDTA method 2. Solder Alloy: Sn content by gravimetrically as oxide, Pb content by complexometric method. Bioinorganic Chemistry 1. Estimation of calcium in milk/food sample by EDTA titration. 2. Estimation of iron from iron tablet by colorimetry.
HPLC, GC and Chemistry of Nanomaterials	
2.1	HPLC & GC: 1. To determine efficiency of the given column by using HPLC. 2. To separate three alcohols and determine purity of ethanol from the given mixture using GC. Thermoanalytical Techniques: Theoretical interpretation: 1. Thermal degradation profile of common polymers (PVC, PMMA, PTFA, PI) 2. Kinetics of decomposition of sodium bicarbonate; a differential scanning calorimetry experiment 3. Analysis of the Thermal Properties of Ammonium Nitrate and Polystyrene by Differential Scanning Calorimetry (DSC)

References:

- Advanced Practical Physical Chemistry, J.B. Yadav, Krishna Publisher Media, ISBN -9788182830967
- Experimental Physical Chemistry, V. D Athawale. P. Mathur, New Age International, 2001. ISBN - 81-224-1336-6
- I. Vogel, Quantitative Inorganic Analysis
- J. D. Woolins, Inorganic Experiments
- Palmer, Inorganic Preparations
- G. Raj, Advanced Practical Inorganic Chemistry
- P. C. Kamboj, University Practical Chemistry
- Vogel, Practical Organic Chemistry, 5th edition.
- H. Middleton, Systematic Qualitative Organic Analysis
- Inorganic quantitative analysis by Vogel sixth edition. Pharmacopoeia of India
- Biochemical methods, Sadashivam and Manichem, New age international publication
- General Chemistry experiments by Elias, Universities Press

M. Sc. (CHEMISTRY) SEMESTER I

DISCIPLINE SPECIFIC ELECTIVE Course- II (Theory)

COURSE TITLE: Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis

COURSE CODE: 23PSICHDSEPBS

[CREDITS – 2]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Apply Linear Free Energy Relationship (LFER) and the Hammett equation. (Knowledge/Application) 2. Illustrate the concepts of bioenergetics, including entropy, free energy changes, endergonic and exergonic processes, coupled reactions, and the role of ATP in bioenergetics. 3. Evaluate the structures, synthesis and applications of macromolecules (crown ether, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins) and molecular receptors. 4. Explain the basic theory, working principles, and instrumentation of electrophoresis, including factors affecting separation, resolution, and detection systems.

Learning Objectives:

The module is intended to

1. Study the effect of structure on the rate of reaction.
2. Introduce bioenergetics and Statistical Mechanics in Biopolymers

Module 1: Physico-Organic Chemistry and Bioenergetics		
1.1	Linear free energy relationship (LFER): Introduction and concept in organic chemistry, Hammett equation - substituent constant (σ), reaction constants (ρ), Limitation, Application, Deviations from Hammett equation. The Taft model - Polar substituent constant (σ*), Steric substituent constant (Es), Polar Sensitivity Factor (ρ*), Oka-moto Brown Equation, Yukawa-Tsuno equation	5L
1.2	Bioenergetics: Entropy and free energy changes of a biochemical reaction. Endergonic and exergonic processes, coupled reactions, ATP and its role in bioenergetics. Statistical Mechanics in Biopolymers: Chain Configuration and Conformation of Macromolecules, Statistical distribution end-to-end dimensions, Thermodynamic probability of chain, Calculation of average dimensions for various chain structures. Donnan membrane equilibrium, membrane hydrolysis.	10L
Module 2: Supramolecular Chemistry and Capillary Electrophoresis		
2.1	Supramolecular Chemistry	8L

	Structures, properties and applications of crown ethers, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins. Synthesis of crown ethers, cryptands and calixarenes. Molecular recognition and catalysis, Synthetic molecular receptors: receptors with molecular cleft, molecular tweezers, receptors with multiple hydrogen sites	
2.2	Capillary Electrophoresis Introduction to electrophoresis: basic theory, instrumentation, working, detection system, factor affecting to separation, resolution and application (GE, CE, CGE, SDS-PAGE).	7L

References

Physico-Organic Chemsitry

- John McMurry, Organic chemistry, 8th edition.
- Carruthers and Iain Coldham, Modern methods of Organic Synthesis, 4th edition W. Cambridge University Press, 2004.
- Eric V Anslyn, Dennis A. Dougherty, Modern physical chemistry, University science books, 2006.
- N. S. Isaacs, Physical Organic Chemistry, ELBS/Longman.

Biophysical Chemistry

- U. N. Dash, A Text book of Biophysical Chemistry, Macmillan India Ltd.
- Gurtu and Gurtu, Biophysical Chemistry, Pragati Prakashan

- Avinash Upadhyay, Kakoti Upadhyay, Nirmalendu Nath, Biophysical Chemistry: Principles and Techniques, Himalaya Publishers

Supramolecular Chemistry

- D. Nasipuri - Stereochemistry of Organic Compounds: Principles and Applications
- Jonathan W. Stead and Jerry L. Atwood - Supramolecular Chemistry
- Katsuhiko Ariga, Toyoki Kunitake and Masa kazu Aono - Supramoleculara Chemsitry - Fundamewntal and aplications.

Capillary Electrophoresis

- Capillary Electrophoresis - Methods and Protocols;Philippe Schmitt-Kopplin
- Capillary Electrophoresis: Theory and Practice; PaulD. Grossman, Joel C. Colburn
- Capillary Electrophoresis; Dale R. Baker
- Capillary Electrophoresis; Schmitt-Kopplin Philippe

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Discipline Specific Elective Course- I

COURSE TITLE: Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis

COURSE CODE: 23PS2CHDSEPBS

[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	9	3	2	6	-	20
II	-	4	9	5	2	-	20
Total marks per objective	-	13	12	7	8	-	40
% Weightage	-	32.5	30	17.5	20	-	100

M. Sc. (CHEMISTRY) SEMESTER I

DISCIPLINE SPECIFIC ELECTIVE COURSE PRACTICAL
COURSE TITLE: Physioorganic Chemistry, Bioenergetics, Supramolecular Chemistry and Capillary Electrophoresis

COURSE CODE: 23PSICHDSEPBSP [CREDITS – 2]

Course Learning Outcomes

After the successful completion of the Course, the learner will be able to:

1. Determine substituent constants (σ) using the Hammett equation to understand the effects of substituents on reaction rates and equilibria.
2. Study the statistical distribution of end-to-end distances in polymer chains to grasp their conformational flexibility.
3. Explore applications of supramolecular chemistry, focusing on molecular recognition and self-assembly processes.
4. Apply the fundamental theory and principles of electrophoresis for separating and analyzing biomolecules.

Learning Objectives:

The module is intended to

1. Compute the reaction constant (ρ) to quantify the influence of substituents on the rate of reactions within a series.
2. Gain insight into the different types of chain configurations and conformations in macromolecules and how they affect their properties and behaviors.

3. Calculate and analyze the average dimensions and shapes of different macromolecular chain structures to understand their size and spatial arrangements.

4. Acquire knowledge about the various types of electrophoresis equipment and techniques, including their operation and application in separating and analyzing biomolecules.

Learning Outcomes:

After completion of the course, students shall able to

1. Apply the Hammett equation to calculate substituent constants (σ) for analyzing the electronic effects of substituents on reaction rates and equilibria.
2. Analyze the statistical distribution of end-to-end distances in polymer chains to understand their conformational flexibility and overall structure.

Linear Free Energy Relationships (LFER) in Organic Chemistry:	
1	Determination of Substituent Constant (σ) using the Hammett Equation
2	Determination of Reaction Constant (ρ)
Biopolymers	
1	Chain Configuration and Conformation of Macromolecules
2	Calculation of Average Dimensions for Various Chain Structures
Electrophoresis	
1	Factors Affecting Separation and Resolution in Electrophoresis
2	Applications of Electrophoresis Techniques

Supramolecular Chemistry	
1	Synthesis and Characterization of Host-Guest Complexes
2	Determination of Binding Stoichiometry and Affinity

References:

- Advanced Practical Physical Chemistry, J.B. Yadav, Krishna Publisher Media, ISBN -9788182830967
- Experimental Physical Chemistry, V. D Athawale. P. Mathur, New Age International, 2001. ISBN - 81-224-1336-6
- I. Vogel, Quantitative Inorganic Analysis
- J. D. Woolins, Inorganic Experiments
- Palmer, Inorganic Preparations
- G. Raj, Advanced Practical Inorganic Chemistry
- P. C. Kamboj, University Practical Chemistry
- Vogel, Practical Organic Chemistry, 5th edition.
- H. Middleton, Systematic Qualitative Organic Analysis
- Inorganic quantitative analysis by Vogel sixth edition. Pharmacopoeia of India
- Biochemical methods, Sadashivam and Manichem, New age international publication
- General Chemistry experiments by Elias, Universities Press

M. Sc. (CHEMISTRY) SEMESTER II

Major Course- I (THEORY)

COURSE TITLE: Quantum chemistry and Chemical Kinetics

COURSE CODE: 23PS2CHMJ1QCK

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Apply principles of quantum mechanics to free particle, particle in a box system, harmonic oscillator and rigid rotor systems. 2. Predict a suitable mechanism for evaluation of kinetics of gas phase reactions.

Module 1	Quantum Chemistry	[15L]

Learning Objectives:

The module is intended to

1. Understand the postulates of quantum mechanics and learn how to apply the principles of quantum mechanics to systems such as free particle, particle in a box, harmonic oscillator and rigid rotor

Learning Outcomes:

After the successful completion of the module, the learner will be able to apply principles of quantum mechanics to free particle, particle in a box system, harmonic oscillator and rigid rotor systems.

1.1	Postulates of Quantum Mechanics Time independent Schrödinger wave equation.	[2L]
1.2	Application of quantum mechanics to the following systems: a) Free particle, wave function and energy of a free particle. b) Particle in a one, two and three-dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.	[6L]
1.3	Rigid rotor, spherical coordinates, Schrodinger wave equation in spherical coordinates, separation of the variables, the R equation, the phi equation, the theta equation, wave function, quantization of rotational energy, spherical harmonics. Space quantization of angular momentum.	[7L]

Module 2	Chemical Kinetics	[15L]
Learning Objectives: This module is intended to propose a suitable mechanism for evaluation of kinetics of gas phase reactions.		
Learning Outcomes: After the successful completion of the module, the learner will be able to propose a suitable mechanism and justify kinetics of gas phase reactions.		
2.1	Methods of determining rate laws, Steady state approximation and its applications, Mechanism of photochemical (hydrogen-bromine and hydrogen-chlorine), chain reaction (hydrogen-bromine reaction) consecutive reactions. Inorganic mechanisms: Formation and decomposition of phosgene, decomposition of ozone.	[4L]
2.2	Organic Decompositions: pyrolysis of acetaldehyde, Decomposition of ethane, Decomposition of acetaldehyde	[3L]
2.3	Gas phase reactions: Reaction between H2 and O2, Semenov-Hinshelwood-Thompson Mechanism. Explosion Limits and factors affecting explosion limits.	[2L]
2.4	Activated complex theory, thermodynamic interpretation, comparison of Eyring and Arrhenius equations.	[3L]

2.5	Elementary Reactions in Solution: Solvent Effects on reaction rates, Reaction between ions- influence of solvent dielectric constant, influence of ionic strength	[3L]

References:

- R. P. Rastogi & R. R. Mishra, An Introduction to Chemical Thermodynamics, 6th Revised Edition., Vikas Publishing House PVT Ltd.
- Donald A. McQuarrie and John D. Simon, Physical Chemistry-A Molecular Approach, Viva Books PVT Ltd.
- Peter Atkins and Julio de Paula, Physical Chemistry, 10th Edition, Oxford University Press, Thomson Press (India) Ltd.
- K. L. Kapoor, A Text Book of Physical Chemistry-Thermodynamics and Chemical equilibrium, 4th Edn., Vol.2, Macmillan Publishers India Ltd
- J. Gareth Morris, A Biologist's Physical Chemistry, 2nd edition, ELBS & Edward Arnold Pub. Ltd.
- Quantum Chemistry - Levine
- Handbook of Molecular Physics and Quantum Chemistry - Ermuhammad B. Dushanov Mirzoaziz A. Khusenov
- Elementary Quantum Chemistry - Frank L. Pilar
- Introduction to quantum chemistry - Carole R Gatz
- Quantum Theory for Chemical Applications - Jochen Autschbach
- Principles and Applications of Quantum Chemistry - V.P. Gupta
- Physical Chemistry, Volume 2 - Peter Atkins, Julio de Paula

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Quantum chemistry and Chemical Kinetics

COURSE CODE: 23PS2CHMJ1QCK

[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	-	9	11	-	-	20
II	-	-	10	5	5	-	20
Total marks per objective	-	-	19	16	5	-	40
% Weightage	-	-	47.5	40	12.5	-	100

M. Sc. (CHEMISTRY) SEMESTER II

Major Course- II (THEORY)

COURSE TITLE: Group theory and Inorganic cluster compounds

COURSE CODE: 23PS2CHMJ2GIC

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Identify the symmetry elements, point groups and apply the knowledge to calculate the different vibrational modes of molecules with the help of group theory. 2. Classify inorganic ring, cage and cluster compounds on the basis of their structural type and explore the reactivity, structures and bonding of silicates, boranes, and phosphazenes.

Module 1	Molecular Symmetry and Group theory	[15L]

Learning Objectives:

The module is intended to

1. Introduce the concepts of symmetry elements and group theory.
2. Examine the character table and vibrational modes of molecules.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Assign the point groups to different molecules.
2. Construct the character tables of water and ammonia molecules.

1.1	Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups.	[3L]
1.2	Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules.	[2L]
1.3	Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem. Construction of character tables for point groups C2v, C3v and D2h, structure of character tables, Mulliken notations for irreducible representations.	[5L]
1.4	Reduction formula, application of reduction formula to vibrational modes of water and ammonia molecules.	[3L]

1.5	Group, subgroup relationships, descent and ascent in symmetry, correlation diagrams showing relationship between different groups.	[2L]
Module 2	**Inorganic Rings, Cages and Metal Cluster Compounds**	**[15L]**
Learning Objectives: This module is intended to: 1. Introduce systematic bonding and structure of inorganic cage, cluster compounds. 2. Familiarize with the structure, properties and applications of zeolites.		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Classify the inorganic cluster and cage compounds on the basis of their structural type. 2. Analyze the utility of zeolites in various applications.		
2.1	Silicates: Classification and structure	[2L]
2.2	Bonding in boranes, Wade's rule, STYX number, Heteroboranes Carboranes, Metal-Metal bonding and Metal Clusters, Zintl ions, Electron Count and Structures of Clusters.	[7L]

2.3	Isolobal Analogy and Structures	[2L]
2.4	Aluminosilicates, Zeolites: Synthesis, characterization, determination of surface acidity, shape selectivity and applications.	[2L]
2.5	Phosphazenes: Preparation (N3P3Cl6 and N4P4Cl8), properties and uses.	[2L]

References:

- F. A. Cotton, Chemical Applications of Group Theory, 2 nd Edition, Wiley Eastern Ltd., 1989.
- H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1966.
- R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
- K.V. Reddy, Symmetry and Spectroscopy of Molecules, 2nd Ed., New Age International Publishers, New Delhi, 2009.
- R. Ameta, Symmetry and Group Theory in Chemistry, New Age International Publishers. 2012.
- Gurudeep Raj, Advanced Inorganic Chemistry, Vol- II, Krishna Prakashan Media Pvt.Ltd.
- James Huheey, F. A. Keiter and R.L. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 2006
- Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31 st Edition, Milestone Publishers, 2010.

- S. Pimpalpure, Rashmi Jain,UshaSoni and S.D. Dwivedi, Advanced Inorganic Chemistry, Vol- II, Pragatiprakashan.
- Cotton and Wilkinson, Advanced Inorganic Chemistry, 3 rd Edition.
- Atkin and Shriver, Advanced Inorganic Chemistry, 6th Edition.
- Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004.

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Group theory and Inorganic cluster compounds

COURSE CODE: 23PS2CHMJ2GIC

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	5	5	5	-	3	20
II	-	6	10	4	-	-	20
Total marks per objective	2	11	15	9	-	3	40
% Weightage	5	27.5	37.5	22.5	-	7.5	100

M. Sc. (CHEMISTRY) SEMESTER II

Major Course- III (THEORY)

COURSE TITLE: Organic synthesis and Spectroscopy

COURSE CODE: 23PS2CHMJ3OSS

[CREDITS - 02]

Course Learning Objectives		
After the successful completion of the Course, the learner will be able to: 1. Learners will be able to elaborate the mechanism and applications of specific metallic/non-metallic reagents in organic synthesis. 2. Elucidate the structures of organic molecules using IR, UV-VIS, 1H and 13C NMR		
Module 1	Metals / Non-metals in organic synthesis-I	[15L]
Learning Objective: Learners will be able to elaborate the mechanism and applications of specific metallic /non metallic reagents in organic synthesis.		
Learning Outcome: The module is intended to design organic molecules using specific metallic /non metallic reagents.		

1.1	Organoboron compounds: Preparation and applications of organoborane reagents e.g. 9-BBN, catechol borane, Thexylborane, ICPBH2, IPC2BH in organic synthesis. Hydroboration-mechanism, stereo and regioselectivity. Synthesis of EE, EZ, ZZ dienes and alkynes. Alkylboranes synthesis, mechanism and uses. Functional group reduction by diborane.	[5L]
1.2	Organosilicon compounds: Important features of silicon governing the reactivity of C-Si compounds: preparation and important bond forming reactions of alkyl silanes, alkenyl silanes, aryl silanes and allylsilanes. β-silylcations as intermediate, Peterson olefination.	[4L]
1.3	Silyl enol ethers as enolate precursors, iodotrimethylsilane in organic synthesis.	[2L]
1.4	Organomagnesium, Organolithium and Organo-copper compounds: Preparation and application.	[4L]
Module 2	**Organic Spectroscopy-I**	**[15L]**
Learning Objectives: Learners will be able to understand the applications of IR, UV-VIS, 1H and 13C NMR.		
Learning Outcome: The module is intended to predict the structures of organic molecules using IR, UV-VIS, 1H and 13C NMR.		

2.1	Ultraviolet spectroscopy: Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, solvent polarity. Calculation of absorption maxima by Woodward-Fieser Rules (using Woodward-Fieser tables for values for substituents) for the following classes of organic compounds: conjugated polyenes (cyclic and acyclic), enones and substituted benzene derivatives.	[5L]
2.2	Infrared spectroscopy: Fundamental, overtone and combination bands, vibrational coupling, important group frequencies for the common functional groups, factors affecting vibrational frequencies. Principle and applications of FT-IR.	[3L]
2.3	NMR spectroscopy: (a) Proton magnetic resonance spectroscopy: Chemical shift, Factors affecting chemical shift, Chemical and magnetic equivalence, Spin-spin coupling, coupling constant J, Factors affecting J, First order spectra, Geminal and vicinal coupling (allylic and aromatic). (b) 13C-NMR spectroscopy introduction: 13C chemical shifts, calculation of 13C-chemical shift and examples.	[3L]
2.4	Structure determination involving individual or combined use of the above spectral techniques.	[2L]

References:

- Carruthers and lain Coldham, Modern method of organic synthesis. (Cambridge)William, 4th edition.
- F. A. Caray and R. J. Sundberg, Advance Organic Chemistry Part-B-Plenum Press.
- R.O.C Norman and J.M. Coxon, Principles of organic synthesis. (Nelsons Thoran), 3rd edition.
- V. K. Ahluwalia, Rakesh Kumar Parashar, Organic reaction mechanism. 4th edition.
- P. S. Kalsi, Organic reaction structure and mechanism, 4th edition.
- Clayden, Greeves, Warren and Wothers, Organic Chemistry, (Oxford).
- C. Eabon, Organosilicon Compound.
- H. C. Brown, Organic Synthesis via Boranes.
- T. P. Onak, Organoborane Chemistry.
- W. Gerrard, Organic Chemistry of Boron.
- Donald L. Pavia and Gary M. Lampman, Introduction to Spectroscopy: A Guide for Students of Organic Chemistry.
- Silversteine and Basser, Spectrometric Identification of Organic Compounds.
- P. S. Kalsi, Spectroscopy of Organic compounds.
- J. Bellamy, Infrared spectra of Complex molecules.
- I Fleming, Organic Spectroscopy.

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Organic synthesis and Spectroscopy

COURSE CODE: 23PS2CHMJ3OSS

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	11	9	-	-	-	20
II	7	7	6	-	-	-	20
Total marks per objective	7	18	15	-	-	-	40
% Weightage	17.5	45	37.5	-	-	-	100

M. Sc. (CHEMISTRY) SEMESTER II

Major Course- IV (THEORY)

COURSE TITLE: Separation and spectroscopic techniques

COURSE CODE: 23PS2CHMJ4SST

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Acquire proficiency in using varied chromatographic techniques, solvent extraction methods and its applications. 2. Illustrate principle, Instrumentation and applications of mass spectrometry and NMR spectroscopy

Module 1	Separation Technique II	[15L]

Learning Objectives:

The module is intended to

1. Discuss various chromatographic techniques and its applications.
2. Describe various solvent extraction techniques used in extraction and isolation chemistry.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Acquire proficiency in using chromatography methods like partition chromatography, ion chromatography, and affinity chromatography.
2. Gain knowledge of solvent extraction methods and its applications.

1.1	Partition chromatography, Ion chromatography, Affinity chromatography, HPTLC, Supercritical chromatography, Supercritical fluid extraction, applications.	[8L]
1.2	Solvent extraction: Recapitulation, factors affecting the solvent extraction of inorganic species, separation of metal ions as chelates, ion association, solvation with suitable examples, concept of [pH] 1/2	[7L]
Module 2	**Spectroscopic Technique II**	**[15L]**

Learning Objectives:

This module is intended to:

1. Explain the principles and applications of MS and NMR spectroscopy techniques.
2. Discuss the instrumentation of MS and NMR spectroscopy techniques

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Develop skills in utilizing mass spectrometry for ionization and analysis of compounds, including electron impact, chemical ionization, and electrospray ionization methods
2. Learn about the working principles of NMR spectroscopy and its applications in studying chemical shifts, relaxation processes, and chemical exchange phenomena

2.1	Mass Spectrometry: Introduction, ion source, electron impact source, chemical ionization source, field ionization source, field desorption sources, MALDI, electrospray ionization Mass spectrometer: sample inlet system, mass analysers, magnetic sector analyser, time of flight, quadruple, ion trap, application in organic and inorganic chemistry (Numerical is expected)	[7L]
2.2	Nuclear Magnetic Resonance (NMR): Introduction, Classical and Quantum description of NMR, relaxation process, chemical shift, Abscissa scales for NMR spectra, interpretation of first order spectra, effect of chemical exchange on spectra. NMR spectrometers: Instrumentation, working, applications of 1H NMR, 13C NMR, 31P NMR, 19F NMR. (Numerical is expected)	[8L]

References:

- Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987)
- Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)
- Fundamentals of Analytical Chemistry, D.A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
- Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Edition (1998)
- Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N. Y 1997
- Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- IV COURSE TITLE: Separation and spectroscopic techniques

COURSE CODE: 23PS2CHMJ4SST

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	3	4	4	4	-	-	15
II	3	4	4	4	-	-	15
Total marks per objective	6	8	8	8		-	30
% Weightage	18	24	24	24		-	100

M. Sc. (CHEMISTRY) SEMESTER II

COURSE TITLE: Practical based on MJ1 and MJ4

COURSE CODE: 23PS2CHMJP1

[CREDITS – 1.5]

Physical chemistry - Course Learning Outcomes
After the successful completion of the Course, the learner will be able to get hands-on experience in instrumental and theoretical concepts in thermodynamics.
Learning Objectives: The module is intended to 1. Give hands-on experience in instrumental and theoretical concepts in thermodynamics. 2. Develop skills in using instrumental techniques to study kinetics of reactions. 3. Use the relative order of reactivity of acids to analyze the composition of mixtures 4. Measure the electrical properties of organic acids to compare their reactivity
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Perform experiments to analyze the data and relate it to the theoretical concepts. 2. Use instrumental techniques to study kinetics of reactions

3. Analyze mixture of acids using their relative order of reactivity
4. Compare reactivity of organic acids by measuring their electrical properties

Instrumental Experiments	
1	To study the effect of substituents on the dissociation constant of acetic acid by conductometrically.
2	Kinetic study of alkaline hydrolysis of ethyl acetate by conductometric method.
3	Titration of a mixture of Trichloroacetic acid, Monochloroacetic acid and Acetic acid with sodium hydroxide conductometrically.
4	To estimate the concentration of CH_3COONa salt by titration with HCl conductometrically
5	To determine the rate constant and the order of the reaction between persulphate and iodide ions by colorimetry.
6	To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant.
7	To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base.

Non-Instrumental Experiments	
8	To study the influence of ionic strength on the reaction between $K_2S_2O_8$ and KI.
9	Investigation of the reaction between acetone and iodine.
10	To study the enzyme catalysed reaction using Michaelis-Menten equation.

References

- Advanced Practical Physical Chemistry, J.B. Yadav, Krishna Publisher Media, ISBN - 9788182830967
- Experimental Physical Chemistry, V. D Athawale. P. Mathur, New Age International, 2001. ISBN - 81-224-1336-6.

Analytical Chemistry - Course Learning Outcomes

After the successful completion of the Course, the learner will be able to:

1. Explain the principles and applications of modern chemical instrumentation, experimental design, and data analysis.
2. Develop methods for tracing and measuring new substances, such as metals, non-metals, etc.
3. Collaborative teamwork to solve scientific problems
4. Design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

Learning Objectives:

The module is intended to

1. Describe various analytical methods and instrumentation used in chemical analysis
2. Illustrate the use of instrumental methods like spectroscopic techniques, etc.

1	To determine the amount of HCl and H_2SO_4 and hence weight percent in a mixture of the two by conductometric titration
2	To determine the amount of Fe(II) and Fe(III) present in the given solution by spectrophotometric method using 1:10 phenanthroline solution/ To Determine Fe (III) in the given solution by colorimetric method
3	To determine the amount of Cr(VI) and Mn(VII) in the given solution by simultaneous spectrophotometric method
4	To determine the amount of potassium in the given fertilizer sample by flame photometry
5	To determine percentage purity of sodium carbonate in washing soda by pH metrically
6	To determine the amount of Ti(III) and Fe(II) in the given solution by titration with Ce(IV) potentiometrically

7	To determine the percentage purity of sodium benzoate via non-aqueous potentiometric titration
8	Estimation of dairy whitener by flame photometer for its Na+ content
9	To determine the amount of iodide, bromide and chloride in the given mixture by potentiometric titration using silver nitrate
10	To determine percentage purity of sodium carbonate in washing soda pH metrically

References

- Inorganic quantitative analysis by Vogel sixth edition.
- Pharmacopoeia of India 2022, Eight edition
- Biochemical methods, Sadashivam and Manichem, New age international publication
- General Chemistry experiments by Elias, Universities Press

M. Sc. (CHEMISTRY) SEMESTER II

COURSE TITLE: Practical based on MJ2 and MJ3

COURSE CODE: 23PS2CHMJP2

[CREDITS – 1.5]

Inorganic Chemistry - Course Learning Outcomes
After the successful completion of the Course, the learner will be able to:: 1. Synthesize various coordination compounds. 2. Justify the Werner theory with respect to primary valency and secondary valency. 3. Carry out scientific experiments as well as accurately record and analyse the results of such experiments.
Learning Objectives: The module is intended to 1. Enable the learner to prepare various inorganic compounds. 2. Estimate the amount of metal ions and ligands present in the inorganic complexes.

Synthesis and characterization of the following inorganic preparations:	
1	Potassium trioxalato chromate

2	Bis (ethylenediamine)copper(II) sulphate
3	Tris(thiourea) copper(I) sulphate
4	Chloropentaamminecobalt (III) chloride
5	Synthesis of bis(acetylacetonato)dioxomolybdenum(VI), [MoO2(acac)2] and qualitative estimation of molybdenum.
6	Synthesis of ZnO nanoparticles and study of its UV spectra.
7	Synthesis and Purity of [Mn(acac)3] by TLC.

References

- Vogel, Quantitative Inorganic Analysis
- R. C. Maurya, Inorganic Chemistry.

Organic Chemistry - Course Learning Outcomes

After the successful completion of the Course, the learner will be able to::

1. Carry out specific organic reactions.
2. Purify the organic compounds using the technique of recrystalllization.

Learning Objective:

Learners will be able to understand the use of specific reactions for organic synthesis.

Organic Preparations	
1	Benzoin to Benzil
2	Bromobenzene to p-nitrobromobenzene
3	Anthracene to Anthracene-Maleic anhydride adduct
4	5,5-Diphenylhydantoin from urea and benzyl
5	4-Benzylidene -2-Phenyl oxazol-5-one from hippuric acid and acetic anhydride
6	Anthracene to Anthraquinone
7	Resorcinol to 7-hydroxy-4-methyl coumarin
8	2-naphthol to 1,1'-Bis-2-naphthol

References

- I. Vogel, Practical Organic Chemistry, 5th edition.
- H. Middleton, Systematic Qualitative Organic Analysis.

M. Sc. (CHEMISTRY) SEMESTER II

DISCIPLINE SPECIFIC ELECTIVE Course- I (Theory)

COURSE TITLE: Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid State

COURSE CODE: 23PS2CHDSECCE

[CREDITS – 2]

Course Learning Objectives
Learning Objective: Learners will be able to elaborate the mechanism and applications of specific named reactions
Learning Outcome: After the successful completion of the module, the learner will be able to: 1. Design organic molecules using specific named reactions. 2. Illustrate application of electrochemistry for renewables Energy Sources like batteries and fuel cells 3. Discuss the kinetics of reactions in solid state and Enzyme catalysed reactions.
Learning Objectives: The module is intended to enable the learners to predict the product in name reactions of the carbonyl group based on reaction conditions.

Module 1: Carbonyl chemistry and Name reaction		
1.1	Enolates: Structure and stability of enolates. Generation of enolates using nucleophilic and non-nucleophilic bases. Kinetic and thermodynamic control in regiochemistry of enolates, Reactions of enolates ions.	5L
1.2	Name reactions: Aldol, Claisen, Claisen-Schmidt condensation, Stobbe condensation, Dieckmann reaction. Perkin reaction, Knoevenagel reaction, Benzoin condensation, Mannich reaction, Shapiro reaction, Michael Reaction, Robinson ring annulation, Haloform reaction, Reformatsky reaction	10 L

Learning Objectives

The module is intended to

1. Illustrate application of electrochemistry for renewables Energy Sources like batteries and fuel cells
2. Discuss the kinetics of reactions in solid state and Enzyme catalysed reactions.

Learning Outcomes:

After successful completion of the course learner will be able to

1. Apply the principles of electrochemistry to develop batteries and fuel cells
2. Propose mechanism for the rates of reactions in solid state and Enzyme catalysed reactions

Module 2: Electrochemistry and Kinetics of reactions in solids		
2.1	Batteries: Working principle, cell reactions and cell performances of Lithium batteries (Primary and Secondary), Lithium based conducting polymer batteries, Silver- anode primary batteries, High temperature solid state batteries. Fuel cells: Classification, H_2 – O_2 fuel cell, Alkaline fuel cells, Phosphoric acid fuel cells, Solid polymer electrolyte fuel cells, Solid oxide fuel cells, Biochemical fuel cells.	8L
2.2	Kinetics of reactions in solids: Rate laws for reactions in solid, the parabolic rate law, the first order rate law, the contracting sphere rate law, contracting area rate law. Enzyme Kinetics: Enzyme action, Kinetics of reactions catalysed by enzymes- Michaelis- Menten analysis, Lime weaver –Burk and Eadie analyses, Competitive ,Uncompetitive and Noncompetitive Inhibition	7L
	References Name Reactions and Carbonyl chemistry • W. Carruthers and Iain Coldham, Modern methods of Organic Synthesis, 4 th Edition Cambridge University Press 2004. • Jerry March, March's Advanced Organic Chemistry, 6 th edition, 2007, John Wiley and sons. • V. K. Ahluwalia, R. K. Parashar, Organic Reaction Mechanism, 4 th edition, Narosa Publication.	

- J. Clayden, S. Warren, N. Greeves, P. Wothers, Organic Chemistry, Ist Edition, Oxford University Press (2001).
- Gautam Brahmachari, Organic Name reaction: a unified approach, Narosa publication.
- Name Reactions: A Collection of detailed mechanisms and synthetic applications, Jie Jack Li, Springer-Verlag Berlin Heidelberg

Electrochemistry and Kinetics of reactions in solids

- R. Narayan and B. Vishwanathan, Chemical and Electrochemical Energy Systems, Universities Press (India) Ltd. 1998
- Modern Electrochemistry 1: Ionics, Modern Electrochemistry 2A: Fundamentals of Electrodics, 2nd Edition by John O'M. Bockris Amulya K.N. Reddy.
- Principles of instrumental analysis: Skoog, Holler, Niemann, 9th edition
- Marchs advanced organic chemistry: reactions, mechanism and structures Michael B Smith and Jerry March 6th Edition.
- Chemical Kinetics of Solids, Hermann Schmalzried, Wiley VCH

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER I

Major Course- I COURSE TITLE: Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid State

COURSE CODE: 23PS2CHDSECCE

[CREDITS - 02]

Module	Remembering / Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	9	3	2	6		20
II	-	4	9	5	2		20
Total marks per objective	-	13	12	7	8		40
% Weightage	-	32.5	30	17.5	20	-	100

M. Sc. (CHEMISTRY) SEMESTER II

DISCIPLINE SPECIFIC ELECTIVE Course- I (Practical)

COURSE TITLE: Carbonyl Chemistry Electro Chemistry and Kinetics of Reactions in solid State

COURSE CODE: 23PS2CHDSECCEP [CREDITS – 2]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Separate the components in the binary mixture quantitatively 2. Carry out specific organic reactions and Purify the organic compounds using the technique of recrystallization. 3. Evaluate physical constants using principles of electrochemistry 4. Determine stoichiometry and kinetics of reaction using electrochemical techniques
Learning Objectives: The module is intended to 1. Enable the learner to purify specific organic compounds. 2. Make the learner perform separation techniques for separation of binary mixture. 3. Facilitate the learner to evaluate physical constants using principles of electrochemistry 4. Empower the learner to determine stoichiometry and kinetics of reaction using electrochemical techniques

Learning Outcomes:

After completion of the course, students shall able to

1. Purify organic compounds using various techniques, such as recrystallization, distillation, and chromatography.
2. Use electrochemical methods to measure and evaluate physical constants, such as pH, electrode potentials, and conductivity, enhancing their understanding of how electrochemical principles apply to physical property determination.
3. Apply the appropriate method based on the properties of the compounds and the impurities present.

Chemical separation of binary mixtures:	
1.1	Liquid-liquid mixture
Organic Preparations:	
2.1	Organic Preparations: 1. Solvent free synthesis of Chalcone (Green Synthesis) 2. Bromination of acetanilide (Green synthesis)
Electrochemistry:	
2.2	1. Determination of mean ionic activity coefficient of an electrolyte by emf measurements. 2. To determine the CMC of Sodium Lauryl Sulphate from measurement of conductivities at different concentrations.

	3. To determine the formula of the zinc ferrocyanide complex by titration of zinc (II) sulphate with potassium ferrocyanide $K_4[Fe(CN)_6].3H_2O$. 4. To determine the rate constant & order of the reaction between persulfate and iodide ions by colorimetry. 5. To investigate the autocatalytic reaction between potassium permanganate and oxalic acid.

References

Chemical separation of binary mixtures and Organic Preparations:

- Vogel, Practical Organic Chemistry, 5th edition.
- H. Middleton, Systematic Qualitative Organic Analysis.

References

Electrochemistry:

- Advanced Practical Physical Chemistry, J.B. Yadav, Krishna Publisher Media, ISBN - 9788182830967
- Experimental Physical Chemistry, V. D Athawale. P. Mathur, New Age International, 2001. ISBN - 81-224-1336-6
- I. Vogel, Quantitative Inorganic Analysis
- J. D. Woolins, Inorganic Experiments
- Palmer, Inorganic Preparations
- G. Raj, Advanced Practical Inorganic Chemistry
- P. C. Kamboj, University Practical Chemistry
- Vogel, Practical Organic Chemistry, 5th edition.
- H. Middleton, Systematic Qualitative Organic Analysis

M. Sc. (CHEMISTRY) SEMESTER I

DISCIPLINE SPECIFIC ELECTIVE - II (Theory)

COURSE TITLE: Nanochemistry and Renewable Energy Resources

COURSE CODE: 23PS2CHDSENRE [CREDITS – 2]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Recall types and synthesis methods of nanomaterials. 2. Illustrate properties of nanomaterials and identify important nanomaterials and their applications. 3. Classify solar cells and understand their key elements. 4. Explain principles and applications of wind and geothermal energy.

Module 1:	Chemistry of Nanomaterials	15 L

Learning Objectives:

The module is intended to

1. Develop a comprehensive understanding of nanomaterials, encompassing their types, synthesis methods and properties.
2. Explore nanomaterials diverse applications in fields like electronics, medicine, infrastructure, automobiles, agriculture, and beyond.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Describe various types of nanomaterials, delineate the synthesis techniques involving physical, chemical, and biological methods.

2. Characterize significant nanomaterials like carbon nanotubes and Major-shell particles, its wide-ranging applications.		
1.1	Introduction, types of Nanomaterials Synthesis of Nanomaterials: Physical methods, Chemical methods and biological methods. Properties of Nano material: Mechanical, structural, electrical, optical and magnetic properties.	8L
1.2	Some important Nanomaterials: carbon nanotubes, porous silicon, Major shell particles, Au and Ag Nano material. Applications of Nanomaterials: Electronic, Medicine, Infrastructure, automobiles, Agriculture, etc.	7L
Module 2:	**Renewable Energy Sources**	**15L**
Learning Objectives: The module is intended to 1. Understand the classification and applications of solar cells, modules, panels, and arrays. 2. Develop a comprehensive understanding and applications of wind energy and geothermal energy.		
Learning Outcomes: After the successful completion of the module, the learner will be able to:		

1. Categorize solar cells into first, second, and third generations, delineating the characteristics of each.
2. Describe the principles, advantages, disadvantages and applications of wind and geothermal energy.

2.1	Solar Cell - Classification of Solar cells - (1) First generation - Single crystalline, Poly crystalline, (2) Second Generation - Thin film, CdS, CIGs, (3) Third Generation - Polymer based, DSSC, Perovskites, Hybrid, Quantum Dots, Multi Junction Tandem cells. (And/Or) Organic, Inorganic and Hybrid cells. Key elements of Silicon Solar cell, PV Solar cell, Module, panel and array. Solar thermal systems types, applications of Solar PV and Solar Thermal systems.	7L
2.2	Wind Energy: Introduction, Principle of wind energy conversion, Advantages and disadvantages of wind mills, Applications of wind energy.	4L
2.3	Geothermal energy: Introduction, Estimates of Geothermal Power, Nature of geothermal fields, Geothermal resources, Hydrothermal (convective) Resources, Geo pressured resources	4L

References

Nano Chemistry

- Nano-chemistry; Kenneth J. Klabunde, Gleb B. Sergeev
- Nanochemistry: A Chemical Approach to Nanomaterials; Geoffrey A Ozin, André Arsenault
- Nanomaterials and Nanochemistry; C. Bréchignac, P. Houdy, M. Lahmani.

Renewable Energy Sources

- Solar Energy Principles, Thermal Collection & Storage, S.P.Sukhatme: Tata McGraw Hill Pub., NewDelhi
- Non-Conventional Energy Sources, G.D.Rai, NewDelhi
- Renewable Energy, power for a sustainable future, Godfrey Boyle,2004,
- The Generation of electricity by wind, E. W. Golding.
- Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub.,2009.
- Fundamentals of Renewable Energy Resources by G.N.Tiwari, M.K.Ghosal, Narosa Pub., 2007
- Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009. (Ch:6)
- Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India., 2016. (Ch:2, 4)
- Solar Cells: From Materials to Device Technology edited by S. K. Sharma, Khuram Ali, Springer (2020)
- Rational Design of Solar Cells for Efficient Solar Energy Conversion edited by Alagarsamy Pandikumar, Ramasamy Ramaraj, Wiley (2018).
- Energy fables, Edited by edited by Jenny Rinkinen, Elizabeth Shove, Jacopo Torriti, Routledge a T&F group, (2019).

Question paper Template

M. Sc. (CHEMISTRY) SEMESTER II

DISCIPLINE SPECIFIC ELECTIVE - II

COURSE TITLE: Nanochemistry and Renewable Energy Resources

COURSE CODE: 23PSICHDSENRE

[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	15	-	3	2	-	15
II	-	6	2	8	2	2	15
Total marks per objective	-	21	2	11	4	2	30
% Weightage	-	52.5	5	27.5	10	5	100

M. Sc. (CHEMISTRY) SEMESTER II

DISCIPLINE SPECIFIC ELECTIVE Course- II (Practical)

COURSE TITLE: Nanochemistry and Renewable Energy Resources COURSE CODE: 23PS2CHDSENREP [CREDITS – 2]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Analyze the performance of various solar panels by measuring their efficiency under different conditions, such as varying angles and light intensities, to determine optimal operating conditions. 2. Design, construct, and evaluate small-scale wind turbines, assessing their performance and efficiency in diverse wind conditions to understand practical wind energy conversion. 3. Measure the electrical characteristics of photovoltaic cells, including current-voltage relationships and efficiency, to understand their performance and optimization.
Learning Objectives: The module is intended to 1. Develop the ability to measure and compare the efficiency of various solar panels under different conditions, including changes in angle and light intensity, to determine optimal configurations for maximum energy capture. 2. Acquire skills in the design, construction, and performance analysis of small-scale wind turbines, including evaluating their efficiency and

effectiveness in converting wind energy into mechanical or electrical power.

3. Gain proficiency in measuring the electrical characteristics of photovoltaic cells, including current-voltage relationships, and calculating their efficiency to evaluate their performance in converting solar energy.

Learning Outcomes:

After completion of the course, students shall able to

1. Measure efficiency of various solar panels under different conditions, including changes in angle and light intensity.
2. Analyze the performance of the turbines in different wind conditions, understanding how design and environmental factors influence wind energy conversion.
3. Develop skills in producing biofuels from organic materials and measuring their energy output.

Nanochemistry	
1	Biosynthesis of SnO2 nanoparticles/Ag nanoparticles and characterization by UV-vis spectrophotometer.
2	To determine UV-vis characteristics of chemically synthesized CdS, ZnO, ZnS, Ag and SnO2 nanoparticles

Renewable Energy Resources

1	To measure the efficiency of different types of solar panels under various conditions, such as different angles and light intensities.
2	To build and test small-scale wind turbines, analyzing their performance in different wind conditions.
3	To create biofuels from organic materials and testing their energy output.
4	To determine the electrical characteristics of photovoltaic cells, including current-voltage measurements and efficiency calculations.
5	To test different battery technologies for energy storage, such as lithium-ion and flow batteries.
6	To design and test solar thermal collectors, measuring their efficiency in converting sunlight to heat.
7	To measure the energy efficiency of various appliances and systems, identifying ways to improve efficiency.
8	Project work - To conduct Energy Audit of the Building /Department

References

- Nano-chemistry; Kenneth J. Klabunde, Gleb B. Sergeev
- Nanochemistry: A Chemical Approach to Nanomaterials; Geoffrey A Ozin, André Arsenault
- Solar Energy Principles, Thermal Collection & Storage, S. P. Sukhatme: Tata McGraw Hill Pub., NewDelhi
- Non-Conventional Energy Sources, G.D.Rai, NewDelhi
- Renewable Energy, power for a sustainable future, Godfrey Boyle,2004,
- The Generation of electricity by wind, E. W. Golding.

7. Teaching learning process

The pedagogic methods adopted, involve direct lectures, tutorial discussions, as well as technology- supported presentations. We believe that education is interactive and all sessions between students and teachers are based upon reciprocity and respect.

I) The lectures (of 1 hr duration) delivered to one whole class at a time systematically deal with the themes of the syllabus. This constitutes the Major of the teaching-learning process. The students are provided with bibliographic references and encouraged to go through at least some readings so that they could be more interactive and ask more relevant questions in the class. This also helps obtain knowledge beyond the boundaries of the syllabi.

2) Wherever needed, teachers use audio-video based technology devices (e. g. power point, YouTube videos) to make their presentations more effective. Some courses require that students see a documentary or feature film and course themes are structured so that discussions of these will further nuance the critical engagement of students with ideas introduced in their textual materials.

3) Remedial coaching, bridge courses are adopted to enhance the scope of learning for the learners. Remedial sessions are conducted to offer assistance on certain advanced topics. Bridge courses facilitate the development of a concrete basis for the topics to be learnt in the coming academic year.

8. Assessment Methods

Evaluation Pattern: Theory

- Assessments are divided into two parts: Continuous Internal Assessment (CIA) & Semester End Examination.
- The Semester End Examination shall be conducted by the College at the end of each semester.
- Semester End Examination (external) (30 M)- Duration: 1 hour 30 min

Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	5 M x 4 Q = 20 M	5 M x 3 Q = 15 M
2	II	5 M x 4 Q = 20M	5 M x 3 Q = 15 M

Each question will have four sub questions a, b, c, d out of which any three should be answered.

- For Internal Evaluation CIE 20 M

Evaluation pattern: Practical

- Semester-end evaluation: 30 Marks practical examination for each Course at the end of semester.
- Internal evaluation 20 marks as per the following rubrics

Experimental Work	Experimental Report	Quiz	Total
10 M	5 M	5 M	20M

9. Programme and Course Code Format

The course is coded according to following criteria:

1. First two numbers in each course code indicates year of implementation of syllabus (24- year of implementation is 2023-24)
2. Third letter 'P' designates postgraduate
3. Fourth letter 'S' designate Science discipline and the digit followed is for semester number (S1 – 1st Semester)
4. Letter 'CH' is for Chemistry discipline (CH- Chemistry)

   This forms the programme code 24PSCH. For the further course codes programme code is amended as follows
5. To designate the semester, add the digit (1-4) after S in the programme code. (Eg: 23PS1CH- for semester I)

   For the further course codes, addition to the programme code should be done as per the following instructions.
6. To represent Major courses (MJ) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
7. Research methodology course represented as RM.
8. On-job training represented as OJT.
9. For Discipline specific elective course (DSE) of Semester I - III, (DSE) followed by a three lettered code representing the title of the course are used.
10. 'P' followed by digit indicates practical course number. (Practical course number will be added for semesters only where there is more than one course.