REVA UNIVERSITY
Bengaluru, India

APPLIED SCIENCES

MSc Chemistry HANDBOOK

2021-23

REVA UNIVERSITY
Bengaluru, India

School of Applied Sciences

MSc (Chemistry)
HAND BOOK

2021-22

Rukmini Knowledge Park,
Kattigenahalli, Yelahanka, Bangalore - 560 064
Phone No: +91-080-4696 6966

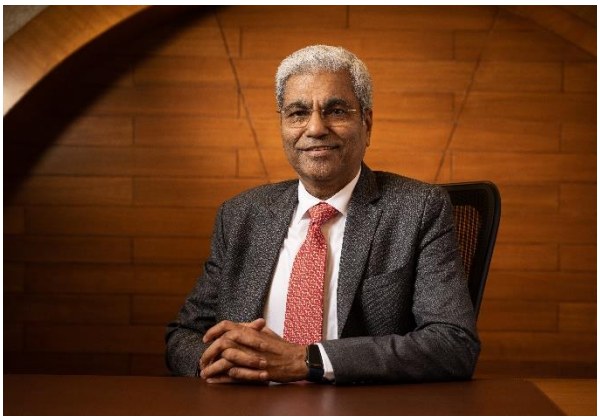
Rukmini Educational
Charitable Trust

www.reva.edu.in

Chancellor's Message

"Education is the most powerful weapon which you can use to change the world."

- Nelson Mandela.



There was a time when survival depended on just the realization of physiological needs. We are indeed privileged to exist in a time when 'intellectual gratification' has become indispensable. Information is easily attainable for the soul that is curious enough to go look for it. Technological boons enable information availability anywhere anytime. The difference, however, lies between those who look for information and those who look for knowledge.

It is deemed virtuous to serve seekers of knowledge and as educators it is in the ethos at REVA University to empower every learner who chooses to enter our portals. Driven by our founding philosophy of 'Knowledge is Power', we believe in building a community of perpetual learners by enabling them to look beyond their abilities and achieve what they assumed impossible.

India has always been beheld as a brewing pot of unbelievable talent, acute intellect and immense potential. All it takes to turn those qualities into power is a spark of opportunity. Being at a University is an exciting and rewarding experience with opportunities to nurture abilities, challenge cognizance and gain competence.

For any University, the structure of excellence lies in the transitional abilities of its faculty and its facility. I'm always in awe of the efforts that our academic board puts in to develop the team of subject matter experts at REVA. My faculty colleagues understand our core vision of empowering our future generation to be ethically, morally and intellectually elite. They practice the art of teaching with a student-centered and transformational approach. The excellent infrastructure at the University, both educational and extra-curricular, magnificently demonstrates the importance of ambience in facilitating focused learning for our students.

A famous British politician and author from the 19th century - Benjamin Disraeli, once said 'A University should be a place of light, of liberty and of learning'. Centuries later this dictum still inspires me and I believe, it takes team-work to build successful institutions. I welcome you to REVA University to join hands in laying the foundation of your future with values, wisdom and knowledge.

Dr. P. Shyama Raju
The Founder and Hon'ble Chancellor, REVA University

Vice-Chancellor's Message

The last two decades have seen a remarkable growth in higher education in India and across the globe. The move towards inter-disciplinary studies and interactive learning have opened up several options as well as created multiple challenges. India is at a juncture where a huge population of young crowd is opting for higher education. With the tremendous growth of privatization of education in India, the major focus is on creating a platform for quality in knowledge enhancement and bridging the gap between academia and industry.

A strong believer and practitioner of the dictum "Knowledge is Power", REVA University has been on the path of delivering quality education by developing the young human resources on the foundation of ethical and moral values, while boosting their leadership qualities, research culture and innovative skills. Built on a sprawling 45 acres of green campus, this 'temple of learning' has excellent and state-of-the-art infrastructure facilities conducive to higher teaching-learning environment and research. The main objective of the University is to provide higher education of global standards and hence, all the programs are designed to meet international standards. Highly experienced and qualified faculty members, continuously engaged in the maintenance and enhancement of student-centric learning environment through innovative pedagogy, form the backbone of the University.

All the programs offered by REVA University follow the Choice Based Credit System (CBCS) with Outcome Based Approach. The flexibility in the curriculum has been designed with industry-specific goals in mind and the educator enjoys complete freedom to appropriate the syllabus by incorporating the latest knowledge and stimulating the creative minds of the students. Bench marked with the course of studies of various institutions of repute, our curriculum is extremely contemporary and is a culmination of efforts of great think-tanks - a large number of faculty members, experts from industries and research level organizations. The evaluation mechanism employs continuous assessment with grade point averages. We believe sincerely that it will meet the aspirations of all stakeholders – students, parents and the employers of the graduates and postgraduates of REVA University.

At REVA University, research, consultancy and innovation are regarded as our pillars of success. Most of the faculty members of the University are involved in research by attracting funded projects from various research level organizations like DST, VGST, DBT, DRDO, AICTE and industries. The outcome

of the research is passed on to students through live projects from industries. The entrepreneurial zeal of the students is encouraged and nurtured through EDPs and EACs.

REVA University has entered into collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students. REVA University has entered into collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students become skilled with relevant to industry requirements. Structured training programs on soft-skills and preparatory training for competitive exams are offered here to make students more employable. 100% placement of eligible students speaks the effectiveness of these programs. The entrepreneurship development activities and establishment of "Technology Incubation Centers" in the University extend full support to the budding entrepreneurs to nurture their ideas and establish an enterprise.

With firm faith in the saying, "Intelligence plus character –that is the goal of education" (Martin Luther King, Jr.), I strongly believe REVA University is marching ahead in the right direction, providing a holistic education to the future generation and playing a positive role in nation building. We reiterate our endeavour to provide premium quality education accessible to all and an environment for the growth of over-all personality development leading to generating "GLOBAL PROFESSIONALS".

Welcome to the portals of REVA University!

Dr. M Dhanamjaya
Vice-Chancellor, REVA University

Director's Message

Higher education across the globe is opening doors of its academic disciplines to the real-world experiences. The disciplinary legitimacy is under critical review. Trans-border mobility and practice learning are being fore-grounded as guiding principles. Interactive learning, bridging disciplines and facilitating learners to gain different competencies through judicious management of time is viewed as one of the greatest and fascinating priorities and challenges today.

The M.Sc. Chemistry is designed keeping in view the current situation and possible future developments, both at national and global levels. This course is designed to give greater emphasis on Research. There are ample number of courses providing knowledge in specialized areas like reaction kinetics, Spectroscopy, Quantum Mechanics, Nanomaterials and analytical techniques, facilitating students to choose specialized areas of their interest. Adequate attention is given to provide students the basic concepts of chemistry and modern computation techniques to be used and knowledge on application of such concepts in practical field. The project, being part of the curriculum will certainly provide students the experience of practical exposure in working environment. The curriculum caters to and has relevance to local, regional, national and global developmental needs. Maximum number of courses are integrated with cross cutting issues with relevant to professional ethics, gender, human values, environmental and sustainability.

The L: T: P structure of teaching and learning under Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) would certainly help our students learn and build competencies needed in this knowledge based society.

This handy document containing brief information about M.Sc. Chemistry, scheme of instruction, course content, CBCS-CAGP regulations and its advantages and calendar of events for the year will serve as a guiding path to students to move forward in a right direction. It would mould them with knowledge, skill and ethical values to face the challenges of this competitive world with greater confidence in becoming proud citizens of mother India.

Prof. Shilpha B R
Director
School of Applied Sciences

CONTENTS

RUKMINI EDUCATIONAL CHARITABLE TRUST

It was the dream of late Smt. Rukmini Shyama Raju to impart education to millions of underprivileged children as she knew the importance of education in the contemporary society. The dream of Smt. Rukmini Shyama Raju came true with the establishment of Rukmini Educational Charitable Trust (RECT), in the year 2002. Rukmini Educational Charitable Trust (RECT) is a Public Charitable Trust, set up in 2002 with the objective of promoting, establishing and conducting academic activities in the fields of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology, among others. In furtherance of these objectives, the Trust has set up the REVA Group of Educational Institutions comprising of REVA Institute of Technology & Management (RITM), REVA Institute of Science and Management (RISM), REVA Institute of Management Studies (RIMS), REVA Institute of Education (RIE), REVA First Grade College (RFGC), REVA Independent PU College at Kattigenahalli, Ganganagar and Sanjaynagar and now REVA University. Through these institutions, the Trust seeks to fulfil its vision of providing world class education and create abundant opportunities for the youth of this nation to excel in the areas of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology.

Every great human enterprise is powered by the vision of one or more extraordinary individuals and is sustained by the people who derive their motivation from the founders. The Chairman of the Trust is Dr. P. Shyama Raju, a developer and builder of repute, a captain of the industry in his own right and the Chairman and Managing Director of the Divya Sree Group of companies. The idea of creating these top notched educational institutions was born of the philanthropic instincts of Dr. P. Shyama Raju to do public good, quite in keeping with his support to other socially relevant charities such as maintaining the Richmond road park, building and donating a police station, gifting assets to organizations providing accident and trauma care, to name a few.

The Rukmini Educational Charitable Trust drives with the main aim to help students who are in pursuit of quality education for life. REVA is today a family of ten institutions providing education from PU to Post Graduation and Research leading to PhD degrees. REVA has well qualified experienced teaching faculty of whom majority are doctorates. The faculty is supported by committed administrative and technical staff. Over 15,000+ students study various courses across REVA's three campuses equipped with exemplary state-of-the-art infrastructure and conducive environment for the knowledge driven community.

ABOUT REVA UNIVERSITY

REVA University has been established under the REVA University Act, 2012 of Government of Karnataka and notified in Karnataka State Gazette No. 80 dated 27th February, 2013. The University is empowered by UGC to award degrees any branch of knowledge under Sec.22 of the UGC Act. The University is a Member of Association of Indian Universities, New Delhi. The main objective of the University is to prepare students with knowledge, wisdom and patriotism to face the global challenges and become the top leaders of the country and the globe in different fields.

REVA University located in between Kempegowda International Airport and Bangalore city, has a sprawling green campus spread over 45 acres of land and equipped with state-of-the-art infrastructure that provide conducive environment for higher learning and research. The REVA campus has well equipped laboratories, custom-built teaching facilities, fully air-conditioned library and central computer centre, the well planned sports facility with cricket ground, running track & variety of indoor and outdoor sports activities, facilities for cultural programs. The unique feature of REVA campus is the largest residential facility for students, faculty members and supportive staff.

REVA consistently ranked as one of the top universities in various categories because of the diverse community of international students and its teaching excellence in both theoretical and technical education in the fields of Engineering, Management, Law, Science, Commerce, Arts, Performing Arts, and Research Studies. REVA offers 28 Undergraduate Programmes, 22 Full-time and 2 Part-time Postgraduate Programmes, 18 Ph. D Programmes, and other Certificate/ Diploma/Postgraduate Diploma Programmes in various disciplines.

The curriculum of each programme is designed with a keen eye for detail by giving emphasis on hands-on training, industry relevance, social significance, and practical applications. The University offers world-class facilities and education that meets global standards.

The programs being offered by the REVA University are well planned and designed after detailed study with emphasis with knowledge assimilation, applications, global job market and their social relevance. Highly qualified, experienced faculty and scholars from reputed universities / institutions, experts from industries and business sectors have contributed in preparing the scheme of instruction and detailed curricula for this program. Greater emphasis on practice in respective areas and skill development to suit to respective job environment has been given while designing the curricula. The Choice Based Credit System and Continuous Assessment Graded Pattern (CBCS – CAGP) of education has been introduced in all programs to facilitate students to opt for subjects of their choice in addition to the core subjects of the study and prepare them with needed skills. The system also allows students to move forward under the fast

track for those who have the capabilities to surpass others. These programs are taught by well experienced qualified faculty supported by the experts from industries, business sectors and such other organizations. REVA University has also initiated many supportive measures such as bridge courses, special coaching, remedial classes, etc., for slow learners so as to give them the needed input and build in them confidence and courage to move forward and accomplish success in their career. The University has also entered into MOUs with many industries, business firms and other institutions seeking their help in imparting quality education through practice, internship and also assisting students' placements.

REVA University recognizing the fact that research, development and innovation are the important functions of any university has established an independent Research and Innovation division headed by a senior professor as Dean of Research and Innovation. This division facilitates all faculty members and research scholars to undertake innovative research projects in engineering, science & technology and other areas of study. The interdisciplinary-multidisciplinary research is given the top most priority. The division continuously liaisons between various funding agencies, R&D Institutions, Industries and faculty members of REVA University to facilitate undertaking innovative projects. It encourages student research projects by forming different research groups under the guidance of senior faculty members. Some of the core areas of research wherein our young faculty members are working include Data Mining, Cloud Computing, Image Processing, Network Security, VLSI and Embedded Systems, Wireless Censor Networks, Computer Networks, IOT, MEMS, Nano- Electronics, Wireless Communications, Bio-fuels, Nano-technology for coatings, Composites, Vibration Energies, Electric Vehicles, Multilevel Inverter Application, Battery Management System, LED Lightings, Renewable Energy Sources and Active Filter, Innovative Concrete Reinforcement, Electro Chemical Synthesis, Energy Conversion Devices, Nano-structural Materials, Photo-electrochemical Hydrogen generation, Pesticide Residue Analysis, Nano materials, Photonics, Nana Tribology, Fuel Mechanics, Operation Research, Graph theory, Strategic Leadership and Innovative Entrepreneurship, Functional Development Management, Resource Management and Sustainable Development, Cyber Security, General Studies, Feminism, Computer Assisted Language Teaching, Culture Studies etc.

The REVA University has also given utmost importance to develop the much required skills through variety of training programs, industrial practice, case studies and such other activities that induce the said skills among all students. A full-fledged Career Development and Placement (CDC) department with world class infrastructure, headed by a dynamic experienced Professor& Dean, and supported by well experienced Trainers, Counsellors and Placement Officers.

The University also has University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director facilitating skill related training to REVA students and other unemployed students. The University has been recognised as a Centre of Skill Development and Training by NSDC (National

Skill Development Corporation) under Pradhan Mantri Kaushal VikasYojana. The Centre conducts several add-on courses in challenging areas of development. It is always active in facilitating student's variety of Skill Development Training programs.

The University has collaborations with Industries, universities abroad, research institutions, corporate training organizations, and Government agencies such as Florida International University, Okalahoma State University, Western Connecticut University, University of Alabama, Huntsville, Oracle India Ltd, Texas Instruments, Nokia University Relations, EMC^2, VMware, SAP, Apollo etc, to facilitate student exchange and teacher–scholar exchange programs and conduct training programs. These collaborations with foreign universities also facilitates students to study some of the programs partly in REVA University and partly in foreign university, viz, M.S in Computer Science one year in REVA University and the next year in the University of Alabama, Huntsville, USA.

The University has also given greater importance to quality in education, research, administration and all activities of the university. Therefore, it has established an independent Internal Quality division headed by a senior professor as Dean of Internal Quality. The division works on planning, designing and developing different quality tools, implementing them and monitoring the implementation of these quality tools. It concentrates on training entire faculty to adopt the new tools and implement their use. The division further works on introducing various examination and administrative reforms.

To motivate the youth and transform them to become innovative entrepreneurs, successful leaders of tomorrow and committed citizens of the country, REVA organizes interaction between students and successful industrialists, entrepreneurs, scientists and such others from time to time. As a part of this exercise great personalities such as Bharat RatnaProf. C. N. R. Rao, a renowned Scientist, Dr. N R Narayana Murthy, Founder and Chairman and Mentor of Infosys, Dr. K Kasturirangan, Former Chairman ISRO, Member of Planning Commission, Government of India, Dr.Balaram, Former Director IISc., and noted Scientist, Dr. V S Ramamurthy, Former Secretary, DST, Government of India, Dr. V K Aatre, noted Scientist and former head of the DRDO and Scientific Advisor to the Ministry of DefenceDr.Sathish Reddy, Scientific Advisor, Ministry of Defence, New Delhi and many others have accepted our invitation and blessed our students and faculty members by their inspiring addresses and interaction.

REVA organises various cultural programs to promote culture, tradition, ethical and moral values to our students. During such cultural events the students are given opportunities to unfold their hidden talents and motivate them to contribute innovative ideas for the progress of the society. One of such cultural events is REVAMP conducted every year. The event not only gives opportunities to students of REVA but also students of other Universities and Colleges. During three days of this mega event students participate in debates, Quizzes, Group discussion, Seminars, exhibitions and variety of cultural events. Another important event is Shubha Vidaaya, - Graduation Day for the final year students of all the programs,

wherein, the outgoing students are felicitated and are addressed by eminent personalities to take their future career in a right spirit, to be the good citizens and dedicate themselves to serve the society and make a mark in their respective spheres of activities. During this occasion, the students who have achieved top ranks and won medals and prizes in academic, cultural and sports activities are also recognised by distributing awards and prizes. The founders have also instituted medals and prizes for sports achievers every year. The physical education department conducts regular yoga class's everyday to students, faculty members, administrative staff and their family members and organizes yoga camps for villagers around.

Vision

REVA University aspires to become an innovative university by developing excellent human resources with leadership qualities, ethical and moral values, research culture and innovative skills through higher education of global standards.

Mission

- To create excellent infrastructure facilities and state-of-the-art laboratories and incubation centres
- To provide student-centric learning environment through innovative pedagogy and education reforms
- To encourage research and entrepreneurship through collaborations and extension activities
- To promote industry-institute partnerships and share knowledge for innovation and development
- To organize society development programs for knowledge enhancement in thrust areas
- To enhance leadership qualities among the youth and enrich personality traits, promote patriotism and moral values.

Objectives

- Creation, preservation and dissemination of knowledge and attainment of excellence in different disciplines
- Smooth transition from teacher - centric focus to learner - centric processes and activities
- Performing all the functions of interest to its major constituents like faculty, staff, students and the society to reach leadership position
- Developing a sense of ethics in the University and Community, making it conscious of its obligations to the society and the nation
- Accepting the challenges of globalization to offer high quality education and other services in a competitive manner.

ABOUT THE SCHOOL OF APPLIED SCIENCES

The School of Applied Sciences offers graduate and post graduate programs in Biotechnology, Biochemistry, Chemistry, Physics and Mathematics which are incredibly fascinating. It aims to attract talented youth and train them to acquire knowledge and skills useful to industrial sectors, research laboratories, and educational institutions. The School presently offers M.Sc. degree programs in Bio-Chemistry, Bio-Technology, Chemistry, Physics, Mathematics and B Sc with various combinations viz, Physics Chemistry and Mathematics, Mathematics , Physics and Statistics, Mathematics Statistics and Computer Science, and Biology Mathematics & Computer Science and also Post Graduate Diploma in Clinical Research Management. The School also facilitates research leading to PhD in Biotechnology, Biochemistry, Physics, Chemistry, Mathematics and related areas of study.

The School of Applied Sciences is shouldered by well qualified, experienced and highly committed faculty. The state-of-the-art infrastructure digital classrooms, well equipped laboratories, conference rooms and the serene academic atmosphere at REVA University will enhance the transfer as well as creation of knowledge. The school provides an interactive, collaborative peer tutoring environment that encourages students to break down complex problems and develop strategies for finding solutions across a variety of situations and disciplines. The school aims to develop a learning community of critical thinkers who serves as models of innovative problems solving in the university environment to enrich their academic and professional careers.

Vision

To nurture intellect, creativity, character and professionalism among students and impart contemporary knowledge in various branches of Chemical, Biological, Physical and Mathematical Sciences that are socially relevant and transform them to become global citizens.

Mission

- To create excellent infrastructure facilities and state-of-the-art laboratories and incubation centres
- To provide student-centric learning environment through innovative pedagogy and education reforms
- To encourage research and entrepreneurship through collaborations and extension activities
- To promote industry-institute partnerships and share knowledge for innovation and development
- To organize society development programs for knowledge enhancement in thrust areas
- To enhance leadership qualities among the youth and enrich personality traits, promote patriotism and moral values.

BOS MEMBERS

Name and Position	
Dr. N. Ramesh Professor and Registrar i/c REVA University Ph: +91-9880514718 E-mail:dean.tpp@reva.edu.in **(Chairperson)**	
Dr. Arun Kumar Gupta Research Director Syngene International Limited, BBRC A Biocon Group, Bangalore Ph: +91-9731133411 E-mail:akg1966@yahoo.com **(External Member - Industry Expert)**	
Dr. Shivaraj Y. Associate Professor Department of Chemistry Bangalore University Ph +91-9972001267 E-mail : shivaraj_y@rediffmail.com **(External Member-Academic)**	
Dr. Madhusudana Reddy M. B. Assistant Director and Professor School of Chemical Sciences REVA University Ph:+91-9480224757 E-mail: madhusudana@reva.edu.in **(Internal Member)**	
Dr. Sakthivel Kandaiah Associate Professor School of Chemical Sciences REVA University Ph:+91-9742585588 E-mail: sakthivel@reva.edu.in **(Internal Member)**	

Dr. Lakshmi B Associate Professor School of Chemical Sciences REVA University Ph:+91-9902632762 E-mail:lakshmib@reva.edu.in **(Internal Member)**	
Dr. Nagendra G. Assistant Professor School of Chemical Sciences Reva University Ph:+91-9844722805 E-mail: nagendra.g@reva.edu.in **(Internal Member)**	
Miss. Megha Dash R18MCH010 **(Alumni Student)**	

M.Sc. (Chemistry) Program Overview

Chemical sciences are branch of the natural sciences dealing with the composition of substances and their properties and reactions. The chemical sciences provide understanding of the physical and chemical properties of atoms and molecules and practical methods for creating new molecular structures with useful applications. Chemistry is a 'platform science', contributing to fundamental aspects of a range of other sciences and underpinning the dramatic advances seen in recent decades in such fields as biotechnology, energy, the environment, genetics, materials and medicine.

Since the mid-20thcentury, the importance of S&T for development has increasingly been recognized by international agencies, development assistance partners and the governments of low- and middle-income countries (LMICs). One outstanding example of success is the case of Taiwan, whose per capita Gross National Product rose from US$ 919 in the 1950s to US$ 7358 in 1990, as the agrarian economy was transformed into an export-oriented industrial one. By the early 1990s, the chemical industry was the largest industrial sector, contributing 24.2% of the total production value of US$ 165.3 billion, but only 8.5% directly to export sales of US$ 95.6 billion. This demonstrates the strategic importance of the chemical industry as a supplier of materials and chemicals in underpinning other export industries, including electrical/electronic goods and textiles.

Chemistry is important in storage and use of energy, Creation of new materials, Advances in agriculture, food and nutrition, Better health and Economic growth. Thus, Chemistry is an essential part of the educational system of an advanced society. Indian Society has embraced knowledge economy and its economic growth rate is one of the highest in the world. India has shown highest level of progress in engineering, space, nuclear, aeronautics, biotech, and pharmaceutics. The subject of chemistry has played a major role in the development of country.In this context, Universities across the country offer Chemistry as a subject at undergraduate and Chemistry as a programme at postgraduate level.

M.Sc. (Chemistry) program at **REVA UNIVERSITY** has been designed to meet the human resources needs of existing and futuristic research establishments, industries and academic institutions. The program is designed to produce graduates with higher order critical, analytical, problem solving and research skills; ability to think rigorously and independently to meet higher level expectations of industries, research organization and academic institutions.

The program focuses on theoretical and practical aspects of physical, analytical, organic and Inorganic chemistry aspects with opportunities for project work in the subject area. The courses are tailored to prepare students in teaching and research as well as in community activities and development. The minor project work that the students must undertake compulsorily is integrated with industry experience. This will not only enhance acquaintance with applications of chemistry to real world problems but improve students' knowledge and self-confidence. The school also has a research program leading to a doctoral degree. The program focuses on research to offer professional services at National and International levels.

In this context, University Programmes at undergraduate and postgraduate level in Chemistry across the Country have become relevant.

Program Educational Objectives (PEOs)

The aim of the program is to produce postgraduates with - advanced knowledge and understanding of Chemistry; higher order critical, analytical, problem solving and attitudinal skills (transferable) to meet expectations of research establishments, relevant industry and academia. Hence,

After few years of graduation, the graduates of M. Sc Chemistry will:

PEO1 Work as a scientist or faculty in educational institutions and research organizations in a team with further training.

PEO2 Develop strong ethics and communication as consultant with an attitude of lifelong learning.

PEO3 Pursue higher studies and participate in societal activities and address the problems of the society

Program Outcomes (POs)

After successful completetion of the program, the student will be able to:

PO1: Knowledge Sharing: Apply the knowledge of fundamentals mathematics, physics and advanced chemistry to resolve the problems pertaining chemical sciences.

PO2: Problem analysis: Analysis of research problems and chemical structures of compounds and provide solutions at national and international level.

PO3: Design/development of solutions: Design and development of solutions for reactions based on kinetics, thermodynamic, quantum mechanical approaches to solve the chemical structure through mechanistic approaches.

PO4: Conduct investigations of complex problems: Formulate and develop methods and utilize advanced scientific tools and techniques to probe complex chemical problems and interpret the data.

PO5: Research skills: Enhance the research skills and carryout the extensive research literature in advanced chemical studies.

PO6: Environment and sustainability: Apply critical thinking ability to achieve sustainable solutions for energy and environment.

PO7: Ethics: Apply ethical principles and commit to ethics, and responsibilities and norms of the professional practice

PO8: Individual and team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO9: Communication: Communicate effectively with the professional community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

PO10:Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. Lead a team to successfully complete projects, and communicate across teams.

Program Specific Outcomes (PSO)

After successful completion of the program, the student will be able to:

PSO1: Dmonstrate strong foundation in the fundamentals and applications of current chemical and scientific theories of those in Analytical, Inorganic, Organic and Physical Chemistries.

PSO2: Design and carry out scientific experiments as well as accurately record and analyze the results of experiments and skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PSO3: Explore new areas of research in the field of chemical sciences and allied fields of science and technology.

REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Postgraduate Degree programs- 2021

(Framed as per the provisions under Section 35 (ii), Section 7 (x) and Section 8 (xvi) & (xxi) of the REVA University Act, 2012)

1. Title and Commencement:

1.1. These Regulations shall be called the **"REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Post Graduate Degree Programs- 2021".**

1.2. These Regulations shall come into force from the date of assent of the Chancellor.

2. The Programs:

The following programs and all Graduate Degree programs to be instituted and introduced in REVA University in coming years shall follow these regulations.

M.Sc in:

Biotechnology

Biochemistry

Chemistry

Physics

Mathematics

3. Definitions:

Course: Every course offered will have three components associated with the teaching-learning process of the course, namely:

(i) L= Lecture (ii) T= Tutorial (iii) P=Practice;

Where:

L stands for **Lecture** session consisting of classroom instruction.

T stands for **Tutorial** session consisting participatory discussion / self study/ desk work/ brief seminar presentations by students and such other novel methods that make a student to absorb and assimilate more effectively the contents delivered in the Lecture classes.

P stands for **Practice** session and it consists of Hands on Experience / Laboratory Experiments / Field Studies / Case Studies that equip students to acquire the much required skill component.

4. Courses of study and Credits

4.1. The study of various subjects in M. Sc., degree program are grouped under various courses. Each of these course carries credits which are based on the number of hours of teaching and learning.

4.1.1. In terms of credits, every **one hour session of L amounts to 1 credit per Semester** and a minimum of **two hour session of T or P amounts to 1 credit per Semester** over a period of one Semester of 16 weeks for teaching-learning process.

4.1.2. The total duration of a semester is 20 weeks inclusive of semester-end examination.

4.1.3. A course shall have either or all the four components. That means a course may have only lecture component, or only practical component or combination of any two or all the three components.

4.1.4. The concerned BoS will assign Credit Pattern for every course based on the requirement. However, generally, courses can be assigned with 1-4 Credits depending on the size of the course.

4.1.5. Different **Courses of Study** are labelled and defined as follows:

Core Course:

A course which should compulsorily be studied by a candidate as a core-requirement is termed as a Core course. The CORE courses of Study are of THREE types, viz – (i) Hard Core Course, and (ii) Soft Core Course.

A. Hard Core Course (HC):

The **Hard Core Course** is a Core Course in the main branch of study and related branch (es) of study, if any that the candidates have to complete compulsorily.

B. Hard Core Course (HC):

The **Hard Core Course** is a Core Course in the main branch of study and related branch (es) of study, if any that the candidates have to complete compulsorily.

C. Soft Core Course (SC):

A Core course may be a **Soft Core** if there is a choice or an option for the candidate to choose a course from a pool of courses from the main branch of study or from a sister/related branch of study which supports the main branch of study.

D. Open Elective Course (OE):

An elective course chosen generally from other discipline / subject, with an intention to seek exposure to the basics of subjects other than the main discipline the student is studying is called an O**pen Elective Course.**

E. Project Work / Dissertation:

Project work / Dissertation work is a special course involving application of knowledge in solving / analysing /exploring a real life situation / difficult problem. A project work carrying **FOUR or SIX** credits is called **Minor Project** work / **Dissertation.** A project work of **EIGHT, TEN, TWELVE or SIXTEEN** credits is called **Major Project** work / **Dissertation**. **A Project work may be a hard core or a Soft Core as decided by the BoS / concerned.**

5. Eligibility for Admission:

Bachelors Degree of three years with Chemistry subject/Physical Science as one of the cognate / major / optional subjects with 45% (40% in case of candidates belonging to SC/ST) of marks in

aggregate from any recognized University / Institution or any other qualification recognized as equivalent thereto.

6. Scheme, Duration and Medium of Instructions:

6.1. M.Sc., degree program is of 4 semesters - 2 years duration. A candidate can avail a maximum of 6 semesters (3 years) including blank semesters, if any to successfully complete M. Sc. degree. Whenever a candidate opts for blank semester, he/she has to study the prevailing courses offered by the School when he/she resumes his/her studies.

6.2. The medium of instruction shall be English.

7. Credits and Credit Distribution:

7.1. A candidate has to earn 96 credits for successful completion of Two Year Postgraduate degree with a distribution of credits for different courses as given in Table - 1 given below:

Table-1

Credits and Credit Distribution for Two Year Post Graduate degree programs

Course Type	**Credits for Two Year (4 Semesters) Post Graduate Degree Programs**
Core Course	A minimum of 60 but not exceeding 70
DSEC (SC)	A minimum of 14 but not exceeding 30
Open Elective (OE)	A minimum of 04
Project	A minimum of 8
MOOC/Online	A minimum of 2 but not exceeding 8
Total	**90**

7.2. The concerned BOS based on the credits distribution pattern given above shall prescribe the credits to various types of courses and shall assign title to every course including project work, practical work, field work, self-study elective, as **Hard Core (HC)/Core Course (CC) or Soft Core/DSEC (SC) or Open Elective (OE)**. The concerned BOS based on the credits distribution pattern given above shall prescribe the credits to various types of courses and shall assign title to every course including project work, practical work, field work, self-study elective, as **Hard Core (HC)/Core Course (CC) or Soft Core/DSEC (SC) or Open Elective (OE)**.

7.3 Every course including project work, practical work, field work, self-study elective should be entitled as Hard Core (HC) or Soft Core (SC) or Open Elective (OE) by the BoS concerned.

However, following shall be the RULO (REVA Unique Learning Offerings) courses with credits mentioned against them, common to all branches of study. However the BoS of respective program/ discipline shall decide about the total credits for RULO courses.

MOOCCourses		
Sl. No.	**Course Title**	**Number of Credits**
2	MOOC / Swayam/ Coursera/Internship /Soft Skill Training/ Attending conferences/Webinars/Industrial Visits/In-house R&D etc.	4
	Total	**4**

7.4. The concerned BOS shall specify the desired Program Objectives, Program Educational Objectives, Program Specific Outcomes and Course Outcomes while preparing the curriculum of a particular program.

7.5. A candidate can enrol for a maximum of 30 credits and a minimum of 20 credits per Semester. However he / she may not successfully earn a maximum of 30 credits per semester. This maximum of 30 credits does not include the credits of courses carried forward by a candidate.

7.6. Only such full time candidates who register for a minimum prescribed number of credits in each semester from I semester to IV semester and complete successfully 96 credits in 4 successive semesters shall be considered for declaration of Ranks, Medals, Prizes and are eligible to apply for Student Fellowship, Scholarship, Free ships, and such other rewards / advantages which could be applicable for all full time students and for hostel facilities.

8. Add-on Proficiency Certification / Diploma:

8.1. Add- on Proficiency Certification:

To acquire Add on Proficiency Certification a candidate can opt to complete a minimum of 4 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

8.2. Add on Proficiency Diploma:

To acquire Add on Proficiency Diploma, a candidate can opt to complete a minimum of 18 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

The Add on Proficiency Certification / Diploma so issued to the candidate contains the courses studied and grades earned.

9. Assessment and Evaluation:

A. Each course is assessed for a total weight of 100%. Out of the total 100% weight; 50% weight is for Continuous Internal Assessment (CIA or IA) and the remaining 50% for the Semester End Examination (SEE). This applicable for theory, laboratory, workshop, studio and any such courses

B. Out of 50% weight earmarked for Internal Assessment (IA)- 15% for test-1, 15% for test-2 and 20% for Assignments/and this is applicable for theory based courses

C. The tests and assignments are conducted as per the semester academic calendar provided by the University.

The details as given in the table:

Component	Description	Conduction	Weight Percentage
C1	Test-1: IA1	8th week from the starting date of semester	15
	Test-2: IA2	16th week from the starting date of semester	15
C2	1 Assignment	7th week	10
	2 Assignment	13th week	10
C3	SEE including practical	between 17th Week-20th Week	50
Results to be Announced			**By the end of 21st Week**

Note: IA or CIA includes C1 and C2

Each test must be conducted for a duration of 60 minutes, setting the test question paper for a maximum of 30 marks. The final examination must be conducted for a duration of 3 hours and the question paper must be set for a maximum of 100 marks.

D. Students are required to complete courses like technical skills, placement related courses, Open electives and any such value addition or specialized courses through online platforms like SWAYAM/NPTEL/Any other reputed online education aggregator. Students are required to choose the courses on the advice of their course coordinator/Director and required to submit the course completion certificate along with percentage of marks/grade scored in the assessment conducted by the online education aggregator. If the online education aggregator has issued a certificate along with the grade or marks scored to students, such courses will be considered for SGPA calculations, in case the aggregator has issued only a certificate and not marks scored, then such courses will be graded through an examination by concerned School. The Online/MOOCs courses will not have continuous internal assessment component.

Such of those students who would like to discontinue with the open elective course that they have already registered for earning required credits can do so, however, they need to complete the required credits by choosing an alternative open elective course.

Setting question paper and evaluation of answer scripts:

i. For SEE, three sets of question papers shall be set for each theory course out of which two sets will be by the internal examiners and one set will be by an external examiner. In subsequent years by carrying forward the unused question papers, an overall three sets of question papers should be managed and depending on the consumption of question papers either internal or external examiner be called for setting the question paper to maintain an overall tally of 3 papers with the conditioned mentioned earlier. The internal examiner who sets the question paper should have been course tutor.

ii. The Chairman of BoE shall get the question papers set by internal and external examiners.

iii. There shall be single valuation for all theory papers by internal examiners. However, there shall be moderation by the external examiner who has the subject background. In case no external examiner with subject background is available, a senior faculty member within the discipline shall be appointed as moderator.

iv. The SEE examination for Practical work / Field work / Project work/Internship will be conducted jointly by internal and external examiners as detailed below: However, the BoE on its discretion can also permit two internal examiners.

v. If a course is fully of (L=0): T :(P=0) type or a course is partly P type i.e, (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

10. Evaluation of Practical's and Minor Project / Major Project / Dissertation:

10.1. A practical examination shall be assessed on the basis of:

A. Knowledge of relevant processes;

B. Skills and operations involved;

C. Results / products including calculation and reporting.

10.2. In case a course is fully of P type (L=0:T=0:P=4), the performance of a candidate shall be assessed for a maximum of 100 marks as explained below:

A. Continuous Internal assessment (CIA) = 50 marks.

B. Semester end practical examination (SEE) = 50 marks.

I	Conduction of regular practical throughout the semester	20 marks
Ii	Maintenance of lab records /industry reports/SDP reports	15 marks
Iii	Laboratory test and viva	15 marks
	Total	**50 marks**

The 25 marks for continuous assessment shall further be allocated as under (IA or CIA):

The 50 marks meant for Semester End Examination shall be allocated as under:

i	Conduction of semester end practical examination	30 marks

ii	Write up about the experiment / practical conducted	10 marks
iii	Viva Voce	10 marks
	Total	50 marks

10.3. The SEE for Practical work will be conducted jointly by internal and external examiners. However, if external examiner does not turn up, then both the examiners will be internal examiners. In case a course is partly P type i.e, (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

10.4. The duration for semester-end practical examination shall be decided by the concerned School Board.

10.5. Evaluation of Minor Project / Major Project / Dissertation:

Right from the initial stage of defining the problem, the candidate must submit the progress reports periodically and present his/her progress in the form of seminars in addition to the regular discussion with the supervisor. At the end of the semester, the candidate has to submit final report of the project / dissertation, as the case may be, for final evaluation. The components of evaluation are as follows:

1	First Dissertation presentation describing the problem definition	Should be done a semester before the project semester	Weightage: 0%
2	Dissertation Progress presentation-1	7th week from the start date of project semester	Weightage: 25%
3	Dissertation progress presentation-2	14th Week from the start date of project semester	Weightage -25%
4	Final project Viva and Dissertation Submission	17th-20th Week of project Semester	Weightage: 30% for Dissertation Weightage : 20% for Final Viva Voce

11. Provision for Appeal:

If a candidate is not satisfied with the evaluation of C1, C2 components, he/she can approach the grievance cell with the written submission together with all facts, the assignments, test papers etc, which were evaluated. He/she can do so before the commencement of semester-end examination. The grievance cell is empowered to revise the marks if the case is genuine and is also empowered to levy penalty as prescribed by the university on the candidate if his/her submission is found to be baseless and unduly motivated. This cell may recommend taking disciplinary/corrective action on an evaluator if he/she is found guilty. The decision taken by the grievance cell is final.

For every program there will be one grievance cell. The composition of the grievance cell is as follows:-

- The Registrar (Evaluation) - Ex-officio Chairman / Convener.
- One Senior Faculty Member (other than those concerned with the evaluation of the course concerned) drawn from the school / department/discipline and/or from the sister schools / departments/sister disciplines – Member.
- One Senior Faculty Members / Subject Experts drawn from outside the University school / department – Member.

12. Eligibility to Appear Semester End Examination (SEE)

12.1. Only those students who fulfil a minimum of 75% attendance in aggregate of all the courses including practical courses / field visits etc, as part of the course(s), as provided in the succeeding sections, shall be eligible to appear for SEE examination.

12.2. Requirements to Pass a Course

Students are required to score a total minimum of 40% (Continuous Internal assessment and SEE) in each course offered by the University/ Department for a pass (other than online courses) with a minimum of 20 (40% of 50) marks in final examination

13. Requirements to Pass the Semester

To pass the semester, a candidate has to secure minimum of 40% marks in each subject / course of the study prescribed in that semester.

13.1. Provision to Carry Forward the Failed Subjects / Courses:

A student who has failed in a given number of courses in odd and even semesters of first year shall move to third semester of second and final year of the study. However, he / she shall have to clear all courses of all semesters within the double duration, i. e., within four years of admission of the first semester failing which the student has to re-register to the entire program.

13.2. Provision to Withdraw Course:

A candidate can withdraw any course within ten days from the date of notification of final results. Whenever a candidate withdraws a course, he/she has to register for the same course in case it is hard core course, the same course or an alternate course if it is Soft Core Course or Open Elective Course.

A DROPPED course is automatically considered as a course withdrawn.

13.3. Re-Registration and Re-Admission:

A. In case a candidate's class attendance in aggregate of all courses in a semester is less than 75% or as stipulated by the University, such a candidate is considered as dropped the semester and is not allowed to appear for end semester examination (C3) and he / she shall have to seek re-admission to that semester during subsequent semester / year within a stipulated period.

B. In such case where in a candidate drops all the courses in a semester due to personal reasons,

it is considered that the candidate has dropped the semester and he / she shall seek re-admission to such dropped semester.

14. Attendance Requirement:

14.1. All students must attend every lecture, tutorial and practical classes.

14.2. In case a student is on approved leave of absence (e g:- representing the university in sports, games or athletics, placement activities, NCC, NSS activities and such others) and / or any other such contingencies like medical emergencies, the attendance requirement shall be minimum of 75% of the classes taught.

A. Any student with less than 75% of attendance in aggregate of all the courses including practical courses / field visits etc, during a semester shall not be permitted to appear to the end semester (C4) examination and such student shall seek re-admission as provided in 7.8.4.

B. Teachers offering the courses will place the above details in the School Board meeting during the last week of the semester, before the commencement of C3, and subsequently a notification pertaining to the above will be brought out by the Director of the School before the commencement of C3 examination. A copy of this notification shall also be sent to the office of the Registrar & Registrar (Evaluation).

15. Absence during Mid Semester Examination:

In case a student has been absent from a mid-semester (C1, C2) examination due to the illness or other contingencies he / she may give a request along with necessary supporting documents and certification from the concerned class teacher / authorized personnel to the concerned Head of the School, for make-up examination. The Head of the School may consider such request depending on the merit of the case and after consultation with course instructor and class teacher, and arrange to conduct a special test for such candidate(s) well in advance before the C3 examination of that respective semester. Under no circumstances C1, C2 test shall be held after C3 examination.

16. Grade Card and Grade Point

16.1. **Provisional Grade Card**: The tentative / provisional grade card will be issued by the Registrar (Evaluation) at the end of every semester indicating the courses completed successfully. The provisional grade card provides **Semester Grade Point Average** (SGPA).

16.2. **Final Grade Card:** Upon successful completion of M.Sc., Degree a Final Grade card consisting of grades of all courses successfully completed by the candidate will be issued by the Registrar (Evaluation).

16.3. **The Grade and the Grade Point:** The Grade and the Grade Point earned by the candidate in the subject will be as given below.

Marks P	**Grade G**	**Grade Point (GP=V x G)**	**Letter Grade**
90-100	10	v*10	O

80 - 89	9	v*9	A+
70 - 79	8	v*8	A
60 - 69	7	v*7	B+
55 -59	6	v*6	B
50 - 54	5.5	V*5.5	C +
40 - 49	5	v*5	C
0-39	0	v*0	F
ABSENT			AB

O - Outstanding; A-Excellent; B-Very Good; C-Good; D-Fair; E-Satisfactory; F - Fail
Here, P is the percentage of marks (P= [C1+C2+C3]) secured by a candidate in a course which is **rounded to nearest integer**. V is the credit value of course. G is the grade and GP is the grade point.

16.3.1 Computation of SGPA and CGPA

The Following procedure to compute the Semester Grade Point Average (SGPA).

The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student in a given semester, i.e:

SGPA (Si) = ∑ (Ci x Gi) / ∑Ci Where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course.

Illustration for Computation of SGPA and CGPA

Illustration No. 1

Course	Credit	Grade Letter	Grade Point	Credit Point (Credit x Grade)
Course 1	4	A+	9	4X9=36
Course 2	4	A	8	4X8=32
Course 3	3	B+	7	3X7=21
Course 4	3	O	10	3X10=30
Course 5	3	P	5	3X5=15
Course 6	3	B	6	3X6=18
Course 7	2	O	10	2X10=20
Course 8	2	A	8	2X8=16
	24			188

Thus, **SGPA = 188 ÷ 24 = 7.83**

Course	Credit	Grade letter	Grade Point	Credit Point (Credit x Grade point)

Course 1	4	A	8	4X8=32
Course 2	4	B+	7	4X7=28
Course 3	3	A+	9	3X9=27
Course 4	3	B+	7	3X7=21
Course 5	3	B	6	3X6=18
Course 6	3	P	5	3X5=15
Course 7	2	B+	7	2X7=21
Course 8	2	O	10	2X10=20
	24			**175**

Illustration No. 2

Thus, **SGPA = 175 ÷ 24 = 7.29**

Illustration No.3

Course	**Credit**	**Grade Letter**	**Grade Point**	**Credit Point (Credit x Grade point)**
Course 1	4	O	10	4 x 10 = 40
Course 2	4	A+	9	4 x 9 = 36
Course 3	3	B+	7	3 x 7 = 21
Course 4	3	B	6	3 x 6 = 18
Course 5	3	A+	9	3 x 9 = 27
Course 6	3	B+	7	3 x 7 = 21
Course 7	2	A+	9	2 x 9 = 18
Course 8	2	A+	9	2 x 9 = 18
	24			**199**

Thus**, SGPA = 199 ÷ 24 = 8.29**

Cumulative Grade Point Average (CGPA):

Overall Cumulative Grade Point Average (CGPA) of a candidate after successful completion of the required number of credits (96) for Two year Post Graduate degree program is calculated taking into account all the courses undergone by a student over all the semesters of a program i. e.,

$$CGPA = \sum(Ci \times Si) / \sum Ci$$

Where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Illustration: No.4

CGPA after Final Semester

Semester (ith)	No. of Credits (Ci)	SGPA (Si)	Credits x SGPA (Ci X Si)
1	24	6.83	24 x 6.83 = 163.92
2	26	7.71	26 x 7.71 =200.46
3	24	8.68	24 x 8.68 = 208.32
4	16	9.20	16 x 9.20 = 147.20
Cumulative	90		719.9

Thus, CGPA = 24×6.83+26×7.71+24×8.68+24×9.20 = 7.99 (90)

16.3.2 Conversion of Grades into Percentage:

Conversion formula for the conversion of CGPA into Percentage is:

Percentage of marks scored = CGPA Earned x 10

Illustration: CGPA Earned 8.10 x 10=81.0

16.3.3 Classification of Results

The final grade point (FGP) to be awarded to the student is based on CGPA secured by the candidate and is given as follows.

CGPA	Grade (Numerical Index)	Letter Grade	Performenace	FGP
	G			Qualitative Index
9 >= CGPA 10	10	O	Outstanding	First Class with Distinction
8 >= CGPA < 9	9	A+	Excellent	
7 >= CGPA < 8	8	A	Very Good	First Class
6 >= CGPA < 7	7	B+	Good	
5.5> = CGPA < 6	6	B	Above average	Second Class
> 5 CGPA < 5.5	5.5	C	Average	
> 4 CGPA <5	5	P	Satisfactory	Pass Class
< 4 CGPA	0	F	Not Satisfactory	Unsuccessful

Overall percentage=10*CGPA

Mapping of PEOs with respect to POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
PEO1	√	√	√	√	√	√	√	√	√	√	√	√	√
PEO2	√	√	√	√	√	√	√	√	√	√	√	√	√
PEO3	√	√	√	√	√	√	√	√	√	√	√	√	√

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM 0101	CO1	2	3	2	1			1		1	1	3	2	2
	CO2	2	2	2	1			1		1	1	3	2	2
	CO3	2	2	2	1			1		1	1	3	2	2
	CO4	2	2	2	1			1		1	1	3	2	2
M21SM 0102	CO1	1	2	1	2	3		2				1	1	1
	CO2	1	3		2	3						1	2	2
	CO3	1	2		2	3						2	2	2
	CO4	1	2	1		3					1	1	3	2
M21SM 0103	CO1	1					1			1	2	2		
	CO2						1			1	2	1		
	CO3	1				1	1	1	1	2	2	2		1
	CO4	1				1	1	1	1	2	2	2		2
M21SM 0104	CO1	1	1	2	2	2			1					1
	CO2	2	1	2	2	2			1			1	1	1
	CO3	2	1	1	1	2			2			2	1	2
	CO4	2	2	2	2	3			2			2	3	2
M21SM 0105	CO1	3	3		2	2		1			3	1		2
	CO2	3	3		2	2		1			2	1		
	CO3	3	3		1	1		1			2	1		1
	CO4	3	3		2	1		1			2	1		1
M21SM S101	CO1	2	2	1	2	1	1				1	3	1	1
	CO2	2	2	2	2	1	1				1	3	1	1
	CO3	2	1	2	1	1	1				1	3	2	2
	CO4	2	1	2	2	2	1				1	3	2	3
M21SM S102	CO1	3	2	2	1	2				1	2	3	4	3
	CO2	3	3	3	4	3	1			1	2	3	4	3
	CO3	3	3	3	2	3				1	2	3	4	3
	CO4	3	2	3	1	3	3			1	2	3	3	3
M21SM S103	CO1	3	2	1	1	2	2	2	2	1	2	2	1	1
	CO2	2	2	2	2	3	2	1	2	2	1	2	2	2
	CO3	3	2	2	2	3	2	2	2	3	3	2	2	2
	CO4	3	3	3	2	3	2	1	3	2	2	3	2	1

M21SM 0104	CO1	2	1	1	2	3	1			1	2	2	2	3
	CO2	1	2	1	3	3	1			1	2	1	1	3
	CO3	2	2	2	1	2	1			2	2	1	3	2
	CO4	2	3	2	3	3	2			2	2	2	2	1
M21SM 0106	CO1	3	2	3	1	2	3	2			1	2	3	2
	CO2	2	2	2	3	2	2	2			1	3	2	3
	CO3	2	2	3	1	3	2	3			1	3	3	2
	CO4	3	2	3	1	2	1	2			1	2	2	3
M21SM S107	CO1	1	2	1	2	1	2		2			2	2	2
	CO2	2	1	2	2	2	1		2			1	2	1
	CO3	2	2	2	1	1	2		1			2	1	2
	CO4	2	2	2	2	2	2		2			2		
M21SM 0201	CO1	3	1		2	1	1		2		2	1	2	
	CO2	3	3	2	2	1	1	1	2	1	2	2	2	2
	CO3	3	2	1	2		2		2	2	2	1	1	2
	CO4	2	3	2	1	2	2	2	2	2	3	2	1	3
M21SM 0202	CO1	3	2		2	2	2			1	1	3	2	1
	CO2	3	3	1	2	2	2			1	1	3	2	2
	CO3	3	3	1	2	2	1			1	1	3	2	2
	CO4	2	2	1	2	2	2			1	1	3	2	2
M21SM 0203	CO1	2	3	2	2	2	1			1	2	2	2	2
	CO2	2	2	1	2	2	1			1	2	2	1	2
	CO3	2	3	2	2	2	1			1	2	2	2	3
	CO4	3	3	2	2	2	1			1	2	3	2	3
M21SM 0204	CO1	1	2			3	1	3	1	2	2	2	3	3
	CO2	1	2		1	3	2	3	1	2	2	2	3	3
	CO3	1	2		1	3	2	3	1	2	2	2	3	3
	CO4	1	1			2	1	2	1	2	1	2	1	2
M21SM 0205	**CO1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**			**1**	**3**	**1**	**2**
	CO2	**3**	**2**	**1**	**2**	**2**	**3**	**2**			**1**	**1**	**1**	**3**
	CO3	**2**	**2**	**2**	**3**	**3**	**2**	**1**			**1**	**3**	**1**	**2**
	CO4	**3**	**2**	**1**	**2**	**1**	**2**	**2**			**1**	**3**	**1**	**2**
M21SM S201	CO1	1	1			2	2					2	2	
	CO2	2	1		1	2	1					1	2	2
	CO3	2	2		1	2	2					2		2

	CO4	2	2		2	2	2					2	2	2
M21SM	CO1	2	1	2	1	2	1	1			1	2	1	2
S202	CO2	3	1	1	2	2	1	2			1	2	1	3
	CO3	2	2	2	1	3	2	2			1	2	1	2
	CO4	3	2	1	2	1	2	2			1	3	1	2
M21SM	CO1	2	1	2	1	2	1	1			1	2	1	2
S203	CO2	3	1	1	2	2	1	2			1	2	1	3
	CO3	2	2	2	1	3	2	2			1	2	1	2
	CO4	3	2	1	2	1	2	2			1	3	1	2
M21SM	CO1	2	2		2	1	1					1	2	2
S204	CO2	2	1		2	1	1					2	2	2
	CO3	2	2	1	1	2	2		1			1	2	1
	CO4	2	1	2	2	2	1		2			2	2	2
M21SM	CO1	3	2	2	2	2	2	2	2	2	2	3	1	
0206	CO2	2	3	1	2	2	2	1	1	2	2	3	2	1
	CO3	3	2	2	2	3	2	1	3	3	2	3	2	3
	CO4	2	2	2	3	3	2	1	2	2	2	3	2	3
M21SM	CO1	3	2	1	1	1	2	3	2	2	2	2		2
0207	CO2	1	2	1	1	3	2	2	2	2	2	2		2
	CO3	2	2		1	2	2	2	1	2	2	2		2
	CO4	1	2	1		2	2	2	2	2	1	1		2
M21SM	CO1	2	1	3	3	2	2			1	2	3	3	2
Z301	CO2	4	3	2	2	2	1			1	2	3	3	2
	CO3	2	2		3	3	1			1	2	3	3	3
	CO4	4	3	1	2	2	1			1	2	4	3	3
M21SM	2	2	1	2	2	1			1	1	3	1	2	2
Z302	2	2	1	2	1	1			1	1	2	1	2	2
	2	1	1	2	1	2			2	1	2	1	2	2
	2	1	1	1	1	2			2	2	2	1	2	2
M21SM	CO1	2	2			1	2	2		1	2	3	1	1
Z303	CO2	2	2	2	2	3	2	2	2	1	2	2	3	1
	CO3	2	2	2	3	2	1	2	2	2	2	2	2	1
	CO4	2	2	3	2	3	2	2	2	1	3	2	3	1
M21SM	CO1	2	1		3	1						2	3	1
Z304	CO2	3			3	1						3	3	1

	CO3	3			3	1						2	3	1
	CO4	3			3	1						2	3	1
M21SMS301	CO1	2	1	2			1			1	1	2		1
	CO2	1	1	1			1	1		1	1	2		1
	CO3	1		1		1	2	1	1	1	1	2		
	CO4	1	1	1		1	1	1	1	1	1	1		
M21SMZ305	CO1	3	3	3	3	3	2	1	1	1	2	2	3	2
	CO2	3	3	2	3	3	2	1	2	1	2	2	2	2
	CO3	2	3	2	2	3	2	1	1	1	2	3	2	3
	CO4	2	2	2	2	2	2	2	1	1	2	2	2	2
M21SMZ306	CO1	3	2	2	2	3	2	2		1	2	1	2	2
	CO2	3	2	2	2	2	2	2	2	1	2	2	3	2
	CO3	2	2	2	3	2	1	2	2	2	2	2	2	3
	CO4	2	3	3	2	2	2	2	2	1	2	2	2	2
M21SMZ307	CO1	3	1	2	1	2	3	1			1	2	1	2
	CO2	2	1	2	2	2	1	2			1	2	2	3
	CO3	2	2	1	1	3	2	3			1	3	1	2
	CO4	3	2	2	1	2	1	2			1	2	2	3
M21SMZ308	CO1	3	3		1	3	1	2		1	2	3	2	2
	CO2	1	1	1	1	3	2	2		1	2	4	2	2
	CO3	1	2		2	3	1			1	2	1	2	2
	CO4	1	3		2	3	1	2		1	2	1	2	2
M21SMZ309	CO1	3	2		1	2				1	1	3	2	2
	CO2	3	2	3	3	2				1	1	3	2	2
	CO3	2	2	3	2	2				1	1	3	2	1
	CO4	2	2	2	2	3	2			1	1	3	2	2
M21SMZ310	CO1	1		1	1	1		1	1			1	1	1
	CO2	2	1	2		3	1	2	2			2	2	2
	CO3	2	1	2		3	1	2	2			2	2	2
	CO4	2	1	1		2	1	1	2			2	1	1
M21SMS302	CO1	2	2	1	2	1	2		1			2	2	1
	CO2	3	1	2	2	2	3		2			2	1	2
	CO3	2	3	2	1	2	2		2			1	2	3
	CO4	3	2	2	1	2	1		2			2	2	3
	CO1	3	2	1	3	2		3			1	3	3	2

M21SM Z311	CO2	2	2	1	3	1	1	1		3	1	3	2	2
	CO3	2	2	2	3	2	2	2		2	1	3	2	2
	CO4	2	2	1	1	2	1				1	3	2	1
M21SM Z312	CO1	2	3	3	3	3	3	3	3	1	2	2	3	3
	CO2	2	3	3	3	2	2	3	1	2	2	2	3	3
	CO3	2	2	2	2	3	3	2	2	1	1	2	3	3
	CO4	3	3	3	3	2	2	1	2	1	3	2	3	3
M21SM Z313	CO1	2	2	1	1	1	2	2	1	1	2	2	2	1
	CO2	1	2	2	2	2	2	2	2	1	2	3	2	2
	CO3	2	1	2	3	2	1	3	2	2	2	2	1	1
	CO4	2	2	3	2	2	2	2	2	1	3	3	2	2
M21SM Z314	CO1	2	2	3	3	3	3	1	1	1	2	3	3	3
	CO2	2	3	1	2	2	2	1	2	1	2	3	2	2
	CO3	3	3	1	2	3	1	1	2	1	2	2	2	2
	CO4	2	2	3	3	3	3	1	1	1	2	3	3	3
M21SM Z315	CO1	3	2	1	3	2	3	1	1	1	1	3	2	2
	CO2	3	2	1	1	2	2	1	1	1	1	3	2	2
	CO3	3	2	1	2	2	1	2	1	1	1	3	2	2
	CO4	3	2	3	1	1	1	1	2	1	1	3	2	2
M21SM Z316	CO1	2	1	1	2	1	1	1	2	1	2	2	2	1
	CO2	2	2	2	2	1	2	1	2	1	2	2	2	2
	CO3	2	1	1	1	1	2	1	1	1	1	2	2	2
	CO4	2	1	2	1	1	1	1	1	1	2	2	2	1
M21SM S303	CO1	2	1	2	1	1	2	1	1	2	1	2	1	2
	CO2	1	1	1	2	1	2	1	1	1		1	1	1
	CO3	3	1	2	1	2	1	1	1	1	1	1	1	1
	CO4	2	2	2	2	2	2	1	1	1	1	2	3	2
M21SM Z319	CO1	3	2		2	3		1	1	1	2	3	3	3
	CO2	2	2	1	3	3	2	1	1	1	2	3	2	3
	CO3	3	3		3	3	1	2	1	1	2	4	3	2
	CO4	4	3	1	3	3	1	2	1	1	2	4	4	3
M21SM Z320	CO1	3	3	1		2	1	1	2		2	2	4	3
	CO2	4	3	3	2	3	3	1	2	1	2	3	4	2
	CO3	2	1	3	3	3	2	1	1	1	2	3	4	3
	CO4	1	3	3	2	3	3	1		1	2	2	4	2

M21SM Z321	CO1	3	2	2	1	3	1	2	2	2	1	3	3	3
	CO2	2	1	2	2	3	1	2	2	2	2	2	2	3
	CO3	3	3	2	2	2	1	1	2	2	2	2	2	3
	CO4	3	3	1	2	3	1	1	3	3	2	3	3	3
M21SM Z322	CO1	2	1		3	1						2	3	1
	CO2	3			3	1						3	3	1
	CO3	3			3	1						2	3	1
	CO4	3			3	1						2	3	1
M21SM S304	**CO1**	3	3	1		1	3	3	1	1	3		1	
	CO2	1	3	2	2	1	1	1	1		1		1	1
	CO3	1	3	1	1	1	2	2			1	1	3	1
	CO4	1	2	3	3	3	1	1	1		1	2	3	2
M21SM Z323	CO1	2	3	3	3	3	3	3	3	1	2	2	3	3
	CO2	2	3	3	3	2	2	3	1	2	2	2	3	3
	CO3	2	2	2	2	3	3	2	2	1	1	2	3	3
	CO4	3	3	3	3	2	2	1	2	1	3	2	3	3
M21SM Z324	CO1	2	3	3	3	3	3	3	3	1	2	2	3	3
	CO2	2	3	3	3	2	2	3	1	2	2	2	3	3
	CO3	2	2	2	2	3	3	2	2	1	1	2	3	3
	CO4	3	3	3	3	2	2	1	2	1	3	2	3	3
M21SM O301	CO1	2	2	1	2	1	2			1	1	2	3	1
	CO2	2		2	1	1	1			1	0	1	2	2
	CO3	1		2	1	2	1			1		1	2	2
	CO4	2	1		1	2	1			1	1	1	3	1
M21SM O302	**CO1**	2	2				2		2			2	2	2
	CO2	2	2	3			3		3			2	2	3
	CO3	1	3				2		2			2	1	2
	CO4	2	2	3		2	3		3			2	2	2
M21SM O303	CO1	2	2	1	2	1	2			1	1	2	3	1
	CO2	1		1	1	1	1			1	0	1	2	2
	CO3	1		2	1	2	1			1		2	2	2
	CO4	1	1		1	2	1			1	1	1	3	1
M21SM O304	**CO1**	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**0**	**0**	**1**	**3**	**1**	**2**
	CO2	**3**	**2**	**1**	**2**	**2**	**3**	**2**	**0**	**0**	**1**	**2**	**1**	**3**
	CO3	**2**	**3**	**2**	**3**	**3**	**2**	**1**	**0**	**0**	**1**	**3**	**1**	**2**
	CO4	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**0**	**0**	**1**	**3**	**1**	**3**

M21SMO305	CO1	2			1	1	1				1	1	1	2
	CO2	2			1	1	1				1	1	1	2
	CO3	2			1	1	1				1	1	1	2
	CO4	2			1	1	1				1	1	1	2
M21SMO306	**CO1**	**3**	**1**	**1**	**2**	**1**	**1**	**0**	**0**	**1**	**1**	**2**	**3**	**1**
	CO2	**1**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**1**	**2**	**2**
	CO3	**1**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**1**	**2**	**2**
	CO4	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**3**	**1**
M21SMS401	CO1	2	3	1	2	3				1	2	3	2	3
	CO2	3	3	1	2	3	2			1	2	3	3	3
	CO3	3	3		2	2				1	2	3	3	3
	CO4	3	2	1	2	3	1			1	2	1	1	3
M21SMS402	CO1	3		1	2							3	2	2
	CO2	1	1	2			3					3	2	1
	CO3	2		2	2		2			2		2	2	2
	CO4	3	1	3	3	2	2			2		2	3	2
M21SMS403	CO1	3	2	1	1	1	2	3	2	2	2	2		2
	CO2	1	2	1	1	3	2	2	2	2	2	2		2
	CO3	2	2		1	2	2	2	1	2	2	2		2
	CO4	1	2	1		2	2	2	2	2	1	1		2
M21SMS404	CO1	3	1		3	2		2	2		2	2	2	1
	CO2	2	2	2	3	3		1	2	2	3		2	2
	CO3	3	2	2	2	2	1	2	2	2	2	1	1	2
	CO4	2	3	2	1	2	2	2	2	2	3	2	1	2
M21SMS405	CO1	3	3	1		2	1				2	2	2	3
	CO2	1	3	3	2	3	3			1	2	3	2	2
	CO3	2	1	3	3	3	2			1	2	3	1	3
	CO4	1	3	3	2	3	3			1	2	2	1	2
M21SMS406	CO1	3	2	2	2	1	3	2	1	2	1	3	2	2
	CO2	2	2	3	2	2	2	2	2	2	2	3	3	2
	CO3	2	3	2	3	3	1	2	2	2	2	2	2	3
	CO4	3	1	1	2	2	2	2	2	3	3	2	3	2
M21SMS407	CO1	2	1		2	1						2	2	1
	CO2	2			2	1						2	2	1
	CO3	2	1		1	1						2	2	1

	CO4	2		2			1					2	2	1
M21SM 0S407	CO1	3	2	2	2	2	2		1	1	1	3	3	3
	CO2	3	2		3	2	1				1	3	3	2
	CO3	3	3	3	2	3	1			1	1	3	2	2
	CO4	3	2		2	2	2			1	1	3	3	3
M21SM S408	CO1	2	1	2	2	2	1			1	1	2	2	2
	CO2	2	1	1	2	2	1			1	2	2	1	3
	CO3	2	1	2	2	2	1			2	2	2	2	2
	CO4	3	1	2	2	2	2			1	2	3	2	3
M21SM S409	CO1	3	2	2	2	2	2		1	1	1	3	3	3
	CO2	3	2		3	2	1				1	3	3	2
	CO3	3	3	3	2	3	1			1	1	3	2	2
	CO4	3	2		2	2	2			1	1	3	3	3
M21SM S411	CO1	2	3	3	3	3	3	3	3	1	2	2	3	3
	CO2	2	3	3	3	2	2	3	1	2	2	2	3	3
	CO3	2	2	2	2	3	3	2	2	1	1	2	3	3
	CO4	3	3	3	3	2	2	1	2	1	3	2	3	3

3: highly relevant, 2: moderate, 1: Low

Assessment Table

Hardcore	**COs**	**IA1**	**IA2**	**Assignment**	**SEE**	**Total**	**Hours**
	CO1	7.5		5	12.5	25	15
	CO2	7.5		5	12.5	25	15
	CO3		7.5	5	12.5	25	15
	CO4		7.5	5	12.5	25	15
Softcore	**COs**	**IA1**	**IA2**	**Assignment**	**SEE**	**Total**	**Hours**
	CO1	7.5		5	12.5	25	12
	CO2	7.5		5	12.5	25	12
	CO3		7.5	5	12.5	25	12
	CO4		7.5	5	12.5	25	12

M.Sc. (Chemistry) Program

Scheme of Instructions (Effective for Academic Year 2021-22)

Sl. No.	Course Code	Course Title	Course Type	Credit Pattern and Value L				Weekly Contact Hours	Teaching School/Dept.
				L	T	P	C		
First Semester									
1	M21SM0101	Inorganic Chemistry -I	HC	4	0	0	4	4	Chemistry
2	M21SM0102	Organic Chemistry -I	HC	4	0	0	4	4	Chemistry
3	M21SM0103	Physical Chemistry -I	HC	4	0	0	4	4	Chemistry
4	M21SM0104	Analytical Chemistry- I	HC	4	0	0	4	4	Chemistry
5	M21SM0105	Computers and Mathematics for Chemist	HC / AECC	2	0	0	2	2	Chemistry
Inorganic chemistry									
6	M21SMS101	Introduction to Nano-science and Nanotechnology - I.1	SC*	2	0	0	2	2	Chemistry
Organic Chemistry									
7	M21SMS102	Heterocyclic Chemistry and Chemistry of Bio-Molecules - I.2	SC*	2	0	0	2	2	Chemistry
Physical Chemistry									
8	M21SMS103	Surface, Interfaces and Catalysis - I.3	SC*	2	0	0	2	2	Chemistry
Analytical Chemistry									
9	M21SMS104	Advanced Instrumental Methods of Analysis- I.4	SC*	2	0	0	2	2	Chemistry
Practical Courses									
10	M21SM0106	Organic Chemistry Practicals-I	HC	0	0	2	2	4	Chemistry
11	M21SM0107	Physical Chemistry Practicals-I	HC	0	0	2	2	4	Chemistry
Total				**20**	**0**	**4**	**24**	**30**	
Note:*Students shall choose any **ONE DSEC*- Soft Core (SC)** out of Four Soft Core Courses									
Second Semester									
1	M21SM0201	Inorganic Chemistry -II	HC	4	0	0	4	4	Chemistry
2	M21SM0202	Organic Chemistry -II	HC	4	0	0	4	4	Chemistry
3	M21SM0203	Physical Chemistry -II	HC	4	0	0	4	4	Chemistry
4	M21SM0204	Organic Spectroscopy	HC	4	0	0	4	4	Chemistry

5	M21SM0205	Challenges in Industrial Research and Development	HC / AECC	2	0	0	2	2	Chemistry
Inorganic Chemistry									
6	M21SMS201	Chemistry of Life -II.1	SC*	2	0	0	2	2	Chemistry
Organic Chemistry									
7	M21SMS202	Introduction to Medicinal Chemistry-II.2	SC*	2	0	0	2	2	Chemistry
Physical chemistry									
8	M21SMS203	Advanced Chemical Kinetics and Thermodynamics-II.3	SC*	2	0	0	2	2	Chemistry
Analytical Chemistry									
9	M21SMS204	Separation and Electro Analytical Techniques-II.4	SC*	2	0	0	2	2	Chemistry
Practical Courses									
13	M21SM0206	Inorganic Chemistry Practicals -II	HC	0	0	2	2	4	Chemistry
14	M21SM0207	Analytical Chemistry Practicals-II	HC	0	0	2	2	4	Chemistry
Total				**22**	**0**	**4**	**26**	**30**	
Note:*Students shall choose any **ONE Soft Core** (SC) out of four Soft Core Courses									
Third Semester									
Inorganic Chemistry-III									
1	M21SMZ301	Advanced Inorganic Chemistry III.1	HC	4	0	0	4	4	Chemistry
2	M21SMZ302	Organometallics-III.2	HC	4	0	0	4	4	Chemistry
3	M21SMZ303	Solid state chemistry and Advanced Materials -III.3	HC	4	0	0	4	4	Chemistry
4	M21SMZ304	Structural Methods in Inorganic Chemistry-III. 4	HC	4	0	0	4	4	
5	M21SMS301	Industrial Inorganic Chemistry-III.5	SC*	2	0	0	2	2	Chemistry
6	M21SMS302	Green Chemistry-III .5	SC*	2	0	0	2	2	Chemistry
7	M21SMS303	Energy and Energy Conversion Systems -III.5	SC*	2	0	0	2	2	Chemistry
8	M21SMS304	Environmental Chemistry and Applied Analysis -III.5	SC*	2	0	0	2	2	Chemistry
9	M21SMZ305	Inorganic Chemistry Practicals-III.1	HC	0	0	2	2	4	Chemistry
10	M21SMZ306	Advanced Inorganic Chemistry Practicals-III.2	HC	0	0	2	2	4	Chemistry
Organic Chemistry-III									
1	M21SMZ307	Advanced Organic Chemistry -III.1	HC	4	0	0	4	4	Chemistry
2	M21SMZ308	Advanced Organic Synthesis -III.2	HC	4	0	0	4	4	Chemistry

3	M21SMZ309	Natural Products and Bioorganic Chemistry-III.3	HC	4	0	0	4	4	Chemistry
4	M21SMZ310	Organometallic Chemistry in Organic Synthesis-III.4	HC	4	0	0	4	4	Chemistry
5	M21SMS301	Industrial Inorganic Chemistry-III.5	SC*	2	0	0	2	2	Chemistry
6	M21SMS302	Green Chemistry-III .5	SC*	2	0	0	2	2	Chemistry
7	M21SMS303	Energy and Energy Conversion Systems -III.5	SC*	2	0	0	2	2	Chemistry
8	M21SMS304	Environmental Chemistry and Applied Analysis -III.5	SC*	2	0	0	2	2	Chemistry
9	M21SMZ311	Organic Chemistry Practicals-III.1	HC	0	0	0	2	4	Chemistry
10	M21SMZ312	Advanced Organic Chemistry Practicals-III.2	HC	0	0	0	2	4	Chemistry
Physical Chemistry III									
1	M21SMZ313	Photo-physical Processes and Applications -III.1	HC	4	0	0	4	4	Chemistry
2	M21SMZ314	Fundamentals of Electrochemistry and Applications-III.2	HC	4	0	0	4	4	Chemistry
3	M21SMZ315	Advanced Physical Chemistry -III.3	HC	4	0	0	4	4	Chemistry
4	M21SMZ316	Polymer Science and Technology -III.4	HC	4	0	0	4	4	Chemistry
5	M21SMS301	Industrial Inorganic Chemistry-III.5	SC*	2	0	0	2	2	Chemistry
6	M21SMS302	Green Chemistry-III .5	SC*	2	0	0	2	2	Chemistry
7	M21SMS303	Energy and Energy Conversion Systems -III.5	SC*	2	0	0	2	2	Chemistry
8	M21SMS304	Environmental Chemistry and Applied Analysis -III.5	SC*	2	0	0	2	2	Chemistry
9	M21SMZ317	Physical Chemistry Practicals – III.1	HC	0	0	0	2	4	Chemistry
10	M21SMZ318	Advanced Physical Chemistry Practicals – III.2	HC	0	0	0	2	4	Chemsitry
Analytical Chemistry III									
1	M21SMZ319	Advanced analytical Chemistry -III.1	HC	4	0	0	4	4	Chemistry
2	M21SMZ320	Advanced Materials Analysis and Electron Spectroscopy-III.2	HC	4	0	0	4	4	Chemistry

3	M21SMZ321	Electrochemistry and Electroanalytical Techniques-III.3	HC	4	0	0	4	4	Chemistry
4	M21SMZ322	Instrumental and Analytical Analysis Techniques –III.4	HC	4	0	0	4	4	Chemistry
5	M21SMS301	Industrial Inorganic Chemistry-III.5	SC*	2	0	0	2	2	Chemistry
6	M21SMS302	Green Chemistry-III .5	SC*	2	0	0	2	2	Chemistry
7	M21SMS303	Energy and Energy Conversion Systems -III.5	SC*	2	0	0	2	2	Chemistry
8	M21SMS304	Environmental Chemistry and Applied Analysis -III.5	SC*	2	0	0	2	2	Chemistry
9	M21SMZ323	Analytical Chemistry Practicals – III.1	HC	0	0	0	2	4	Chemistry
10	M21SMZ324	Analytical Chemistry Practicals – III.2	HC	0	0	0	2	4	Chemsitry
Open Elective #									
1	M21SMO301	Advanced Materials in Semiconductor Device Technologies	OE#	4	0	0	4	4	Chemistry to all other schools/Dept.s
2	M21SMO302	Biodiesel : An Alternative Renewable EnergySource	OE*	4	0	0	4	4	Chemistry to all other schools/Dept.s
3	M21SMO303	Chemistry of Materials	OE*	4	0	0	4	4	Chemistry to all other schools/Dept.s
4	M21SMO304	Chemsitry of Food and Beverages	OE#	4	0	0	4	4	Chemistry to all other schools/Dept.s
5	M21SMO305	Nanotechnology	OE*	4	0	0	4	4	Chemistry to all other schools/Dept.s
6	M21SMO306	Sensor Technologies: Physical Sensors, Chemical Sensors, Biosensors, Gas Sensors and their Instrumentation	OE*	4	0	0	4	4	Chemistry to all other schools/Dept.s
Soft Skills (Non Credit)									
27	M21SMM301	Internship / Skill Development	RULO	0	0	-	-	2	Chemsitry/Training & Placement
Total				**20**	**0**	**4**	**24**	**30**	

Note:

i) *Students shall choose any **ONE Soft Core** out of **FOUR** Soft Core Courses in all specialization.

ii) #Open Elective (OE) is offered for students other than chemistry discipline. The students of MSc Chemistry shall choose open elective from other disciplines.

Fourth Semester

1	M21SM0401	Major Project	HC	0	0	8	8	20	Chemistry

2	M21SMS401	Functional inorganic materials	SC*	2	0	0	2	2	Chemistry
3	M21SMS402	Advanced functional organic materials							
4	M21SMS403	Advanced spectroscopy and applications in structural analysis							
5	M21SMS404	Advanced electroanalytical techniques							
6	M21SMS405	Advances in surface, interface and Catalysis							
7	M21SMS406	Advanced materials in energy storage and conversion devices							
8	M21SMS407	Advances in polymer science and technology							
9	M21SMON1	MOOC/SWAYAM/HARVARD/EDX/ Internship/Attending Conferences/Webinars/Industrial Visit/ In-House R&D, etc. (All Semester)	SEC/MOOC	4	0	0	4	4	Chemistry/ others
Practical Courses									
10	M21SMS408	Advanced organic chemistry Practicals-IV.1	SC*	0	0	2	2	4	Chemistry
11	M21SMS409	Advanced Inorganic chemistry Practicals-IV.2	SC*	**0**	0	2	2	4	Chemistry
12	M21SMS410	Physical Chemistry Practicals-IV.3	SC*	**0**	0	2	2	4	Chemistry
13	M21SMS411	Analytical Chemistry Practicals-IV.4	SC*	**0**	0	2	2	4	Chemistry
Total				**6**	**0**	**2**	**16**	**30**	

NOTE:

1. *****Students shall choose **ONE** in each SC and Lab Courses.
2. Major project is compulsory and will begin in 4thSemester. Students will either choose internal guide from the school and continue with in-house projects or choose to do project work either in industry or research organization.

HC=Hard Core; SC=Soft Core; OE=Open Elective;

Credits Semester-wise (2021-23)

Semester	I	II	III	IV	Total
HC-Theory	16	16	16	- -	48
HC-Lab	4	4	4	- -	12

Semester-wise Credit Distribution

SC-Theory	2	2	2	2	8
HC/AECC-Theory	2	2	--	--	4
SC-Lab	- -	- -	- -	2	2
OE	- -	- -	4	- -	4
Project/HC	- -	- -	- -	8	8
SEC/MOOC	- -	--	--	4	4
Total	**24**	**24**	**26**	**16**	**90**

Semesters	No. of Credits	No. of Hours
I	24	30
II	24	30
III	26	30
IV	16	30
Total	**90**	**120**

Semester-wise Course Types & Credit Distribution
Credits Based on L: T: P

Semester	HC	SC	HC/AECC	OE	SEC/MOOC	TOTAL
I	20	2	2	-	-	24
II	20	2	2	-	-	24
III	20	2		4	-	26
IV	8	4		-	4	16
Total	**68**	**10**	**4**	**4**	**4**	**90**

Semester	L	T	P	Total-C	Total Hours
I	20	0	2	24	30
II	22	0	2	26	30
III	20	0	4	24	30
IV	6	0	2	16	30
Total	**41**	**0**	**33**	**90**	**120**

DETAILED SYLLABUS (Effective from the Academic Year 2021-22)

SEMESTER-I: HARD CORE (HC)

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM1010	**INORGANIC CHEMISTRY – I**	HC	4	0	0	4	4

Course Objectives:

This course aims to provide for the student to

i. Learn the Structure, bonding and properties through Lewis, VSEPR, Valence bond and Molecular orbital theory.
ii. Explore the fundamentals of the chemistry of the main group elements include the structure, bonding and properties of Silanes, silicone, boranes, phosphates and inorganic ring system.
iii. Know the classification of acids and bases, HSAB rule, and non-aqueous solvents.
iv. Develop knowledge of the structure, bonding and stability of Metal Clusters, Isopoly, Hetropolyacids and Nobel Gases.

Course Outcomes:

After successful completion of this course, the student will be able to:

CO1: Discuss the principles of bonding, predicting the geometries of simple molecules and properties through VSEPR, Valence bond and Molecular orbital theory.

CO2: Explain the fundamentals of the chemistry of the main group elements include the structure, bonding and properties of Silanes, silicone, boranes, phosphates and inorganic ring system.

CO3: Classify the substances softness and hardness by using HSAB rule and discuss the properties of non-aqueous solvents.

CO4: Develop the knowledge to explain the structure, bonding and stability of Metal Clusters, Isopoly, Hetropolyacids and Nobel Gases.

Course Content:

UNIT-I

Chemical Bonding and Structures: Atomic states and term symbols. Bonding and structure: Types of bonds, orbital symmetry and overlaps, concept of Lewis, hybridization, VSEPR theory, VB theory and MO theory with examples, properties, merits and drawbacks, Born Haber cycle, Born-Lande equation, Kapustinskii equation, partial covalent character, radius-ratio rules, structures of simple solids. Bond energy and covalent radii, concept of resonance, molecular dipole moment; polarizing power and polarizability, Fajan's rules and Slater rules.

UNIT-II

Chemistry of main group elements: Periodic anomalies in main block elements, Inert Pair effect, Relativistic effect.

Boron and Silicon based compounds: Boron hydrides (small boranes and their anions, B1−B4), boron nitride, borazines, carboranes, metalloboranes, metallocarboranes; silicates, silicones, diamond, graphite, zeolites. Nitrogen, Phosphorous, Sulphur and noble gas compounds: Hydrides, oxides and oxy acids of Nitrogen, Phosphorous, Sulphur and halogens; phosphazines, sulphur-nitrogen compounds, inter halogen compounds, pseudo halogens.

UNIT-III

Acid-Bases: Bronsted-Lowry concept, proton transfer equilibria under aqueous conditions, non-aqueous solvents and acid-base strength, periodic trends in aqua acid strength, oxoacids, anhydrous oxides, Bronsted-Lowry acidity of aqueous cations, Lewis acid- base concept and frontier orbitals, examples of Lewis acids and bases, quantification of Lewis basicity, inductive and steric effects on Lewis acidity and basicity, frustrated Lewis pairs.

HSAB concept: Basis of HSAB concept, Frontier MO approach acid-base strength, hardness and softness, symbiosis, applications of HSAB concept and Chatt theory

Non-aqueous solvents: Classification of solvents, Properties of solvents (dielectric constant, donor and acceptor properties) protic solvents (anhydrous H_2SO_4, HF and glacial acetic acid) aprotic solvents (liquid SO_2, BrF_3 and N_2O_4). Solutions of metals in liquid ammonia, hydrated electron. Super acids. Acid- base concept in non-aqueous media.

UNIT-IV

Clusters and Cages: M-M bond and metal atom clusters, halide clusters, bonding in $[ReCl_8]^{2-}$. Metal carbonyl clusters- LNCC's and HNCC's. Electron counting in carbonyl/Nitrosyl clusters, important reactions of metal carbonyls, preparation. Cluster valence electrons and Wade-Mingos-Lauher rules. Structure elucidation based on CVE, Isolobal analogies. Applications of metal clusters.

Isopoly and heteropoly acids of W, Mo and V, preparations, properties, structure and applications, Zintle ions.

Nobel Gases: Preparation, Structure, properties and bonding in halides and oxo-halides of xenon compounds.

References:

1. F.A. Cotton, G. Wilkinson and P.L. Gaus, Basic Inorganic Chemistry, John Wiley and Sons, 3rd Edition, 2002.
2. Inorganic Chemistry, 3rd Edition. James E. Huheey, Harper and Row Publishers (1983).
3. Inorganic Chemistry, 3rdEdition. G.L. Miessler and D.A. Tarr, Pearson Education (2004).
4. Inorganic Chemistry, 2nd Edition. D.F. Shriver, P.W. Atkins and C.H. Langford, Oxford University Press (1994).
5. Inorganic Chemistry, 2nd Edition. C.E. Housecroft and A.G. Sharpe, Pearson Education Ltd. (2005).
6. Introduction to Modern Inorganic Chemistry, K.M. Mackay and R.A. Mackay, Blackie Publication (1989).
7. Principles of Inorganic Chemistry, 33rdEdition, Puri, Sharma, Kalia, Milestone Publications & Distributors, (2018).
8. Advanced Inorganic Chemistry, 2ndEdition, S. P. Banerjee, Books and Allied (p) Ltd, (2017).
9. Chemistry of the Elements, 2ndEdition, N. N. Greenwood, A. Earnshaw, Pergamon Press, (1989).

Mapping of Course Outcomes with program Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
M21SM0101	**CO1**	2	3	2	1			1		1	1	3	1	2
	CO2	2	2	2	1			1		1	1	3	1	2
	CO3	2	2	2	1			1		1	1	3	1	2
	CO4	2	2	2	1			1		1	1	3	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM012	**ORGANIC CHEMISTRY – I**	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Analyze the effect of conjugation, hyperconjugation delocalization, resonance and aromaticity in organic molecules.
ii. Identify the reactive intermediates in the reaction mechanism and also examine the energy profile of the reactions.
iii. Discuss the core concepts of stereochemistry in organic molecules.
iv. Explain the chemistry of carbohydrates, synthesis and biological importance of vitamins.

Course Outcome:

By the completion of course student will be able to

CO1. Explain the effect of conjugation, hyperconjugation delocalization, resonance and aromaticity in organic molecules.
CO2. Analyze role of reactive intermediates such as carbocations, carboanion, carbines, nitrenes and kinetics reaction.
CO3. Predict R/S, E/Z configuration, chirality in molecules by applying concepts of stereochemistry
CO4. Discuss the chemistry of carbohydrates, synthesis and biological importance of vitamins.

Course Content:

UNIT-I

Nature of Bonding and Aromaticity in Organic Molecules-Delocalization, Conjugation, Resonance, Mesomericeffects Inductive effect, Hyperconjugation, Tautomerism, Hybridization. Concepts of Aromaticity, non-aromaticity and antiaromaticity, Aromaticity in non-benzenoids compound, Alternant and non-alternant hydrocarbons, Transition state structure, Hammond postulate, Curtin-Hammett principle, kinetic and thermodynamic control, Hard and soft acids and bases. **[15 hrs]**

UNIT-II

Reaction Mechanisms and intermediates- Generation structure, stability and reactivity of carbocations, carbanions, carbon free radicals, carbenes and nitrenes. Effect of structure on reactivity: Classification of reactions and mechanisms. Nucleophilic substitution reaction at a saturated carbon: S_N1, S_N2, S_Ni .Aromatic Substitution Reactions**:** Electrophilic Substitution Reactions: The arenium ion mechanism. Orientation and reactivity. Energy profile diagrams. Nucleophilic substitution reactions: The SNAr,

ArSN1, and benzyne mechanisms. Elimination Reactions: The E1, E2 and E1cB mechanisms and Orientation of the double bond. Saytzeff and Hoffmann rules. **[15 hrs]**

UNIT-III

Stereochemistry-I: Geometrical isomerism, cis-trans and E-Z nomenclature. Optical isomerism: Elements of symmetry, chirality, topocity, and prochirality. Optical activity, Absolute and relative configurations, D/L, d/l notations. CIP rules, assigning R, S configuration. Methods of resolution of racemic mixtures. Optical activity due to helicity, M P conventions, Chiral derivatizing agents, Chiral solvating agents. Fischer, Newman, Sawhorse and flying wedge projections and their interconversions. Conformational analysis of acyclic (butane) and cyclic alkanes (cyclopentane, cyclohexane mono and di substituted). Conformations in fused rings. **[15 hrs]**

UNIT-IV

Carbohydrates and Vitamins: Introduction, Kiliani-Fischer synthesis, Determination of configuration of the monosaccharides, conformational analysis of monosaccharides. Reactions of Carbohydrates, Synthesis of aldonic, uronic, Aldric acids and alditols. Structure elucidation of sucrose and maltose. Structures of lactose, gentiobiose and meliobiose. Vitamins –Structure and Biological importance of vitamins A C and E. Synthesis of- Vitamin B1 (thiamine), B2(riboflavin), B5(pantothenic acid), B9(folic acid), H (biotin), K1 and K2. **[15 hrs]**

References:

1. Advanced Organic Chemistry – Reactions, Mechanism and Structure, Jerry March, John Wiley (2008)
2. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman, (2000)
3. Stereochemistry of Organic Compounds, D. Nasipuri, New-Age International, (1999)
4. Organic chemistry-Jonathan Clayden, Stuart Warren, Nick Greeves (2001)
5. Organic Chemistry, Volumes I and II, I. L. Finar, Longman, (1999)

6. Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0102	**CO1**	1	2	1	2	3		2				1	1	1
	CO2	1	3		2	3						1	2	2
	CO3	1	2		2	3						2	2	2
	CO4	1	2	1		3					1	1	3	2

Course Objectives:

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0103	PHYSICAL CHEMISTRY - I	HC	4	0	0	4	4

This course aims to provide the student to

i. Correlate the basic concepts of Thermodynamics in the in the day to day life and in the industrial perspective.
ii. Illustrate the quantum statistical methods that uses molecular properties to predict the behavior of macroscopic quantities of compounds.
iii. Conclude the theories of chemical kinetics and study the reactions with advanced flow techniques.
iv. Design the electrode and electrolyte systems by the electrode kinetics using the basic knowledge of the electrochemistry.

Course Outcomes:

By the completion of course student will be able to

CO1. Apply the knowledge of thermodynamic laws to the energy conversion processes in daily life.
CO2. Explain the behavior of microscopic systems with BE, FD, MB statistics and distribution, ensembles, partition functions and molecular partition functions.
CO3. Illustrate the kinetics to the complex reactions, Parallel, consecutive, fast reactions and reversible reactions by the modern flow techniques.
CO4. Judge the Electrochemical reactions by the Debye-Huckel theory, transport numbers, Helmholtz-Perrin, Gouy-Chapman and Stern electrical double layer, reversible and irreversible electrodes to the electrochemical processes.

Course Content:

UNIT – I

Chemical Thermodynamics

Thermodynamics: Brief overview of thermodynamic laws, Concepts of Work, heat, energy, Enthalpy, entropy and free energy. Expansion of work, Molar heat capacities, Joul Thomson experiment, Carnot cycle, Entropy change during spontaneous process. Gibbs and Maxwell relations, Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Third law of thermodynamics - calculation of absolute entropies.

Partial molar properties: Partial molar volumes and their determination by intercept method and from density measurements. Chemical potential and its significance. Variation of chemical potential with temperature and pressure. Formulation of the Gibbs Duhem equation. **[15 hrs]**

UNIT – II

Statistical Thermodynamics

Fugacity: Determination of fugacity of gases. Variation of fugacity with temperature and pressure. Activity and activity coefficients. Variation of activity with temperature and pressure. Determination of activity co-efficient by vapor pressure, depression in freezing point, solubility measurements by electrical methods. Thermodynamics of dilute solutions: Raoult's law, Henry's law. Ideal and non-ideal solutions.

Statistical Thermodynamics: Different ensembles and Partition functions-translational, rotational, vibrational and Electronic partition functions BE, FD, MB statistics and distribution, ensembles, partition functions and molecular partition functions, mean energy, Residual entropy, heat capacity of mono and diatomic gases, Einstein theory of heat capacity of solids. **[15 hrs]**

UNIT – III: **CHEMICAL KINETICS**

Kinetics: Theory of reaction rates, kinetics of complex reactions, Parallel, consecutive and reversible reactions. Determination of order of reaction. Energy of activation and its experimental determination. Simple collision theory - mechanism of bimolecular reaction. Lindemann's theory, Hinshelwood's theory, for unimolecular reaction (No derivation). Activated complex theory of reaction rate, classical thermodynamic treatment, partition function, statistical thermodynamic treatment. Kinetics of reactions in solution - Salt effect, effect of dielectric constant (single sphere and double sphere model), effect of pressure, volume and entropy change on reaction rates.

Fast reactions: Study of kinetics by flow techniques, equation for contact time, stopped flow and continuous flow methods. Relaxation method, equation for relaxation time, temperature jump and pressure jump methods, flash photolysis, pulse radiolysis and shock tube method. Potential energy surface, theoretical calculation of energy of activation. **[15 hrs]**

UNIT – IV: Electro Chemistry

Introduction, Mobility and conductivity of electrolytes, Arrhenius theory of strong and weak electrolytes and its limitations, Concept of activity and activity coefficients in electrolytes, Debye-Huckel theory of strong electrolytes, Debye Huckel-Onsager equation, Debye-Huckel limiting equation for activity co-efficient. A brief survey of Helmholtz-Perrin, Gouy-Chapman and Stern electrical double layer (No Derivation). Liquid junction potential and its determination. Transport Number: Determination of transport number by Hittorf method and e.m.f method. Effect of temperature and concentration on transport number. Reversible and irreversible electrodes, reversible and irreversible cells. Electrode and cell potentials, Polarization, over voltage. Experimental determination of over voltage. decomposition potential Equations for concentration over potential, diffusion current – stationary current, potential curves at a dropping mercury electrode, polarography, half wave potential, application in qualitative and quantitative analysis. Butler-Volmer equation, Tafel equation (No derivation). **[15 hrs]**

References:

1. Thermodynamics for Chemists by S. Glasstone, Affiliated East-West Press, New Delhi, (1965).
2. Chemical Thermodynamics, I.M. Klotz, W.A. Benzamin Inc. New York, Amsterdam (1964).
3. Text Book of Physical Chemistry,2nd edition, Samuel Glasstone, MacMillan Indian Ltd., (1974).
4. Elements of Physical Chemistry, Lewis and Glasstone.
5. Physical Chemistry, P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990).
6. Introduction to Electrochemistry, S. Glasstone.
7. Principles of Physical Chemistry, Puri, LR Sharma and Pathania, Vishal publishing Co.

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21S M0103	CO1	2	1	3	1	1	2		1	1	2	2	1	2
	CO2	1	2	2	1	1			1	1	2	1	1	2
	CO3	1	1	1	2	2	1	1	2	1	2	2	1	1
	CO4	2	1	2	1	1	1	1	1	2	2	2	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0104	ANALYTICAL CHEMISTRY -I	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Application of principles of analytical chemistry in chemistry.
ii. Knowledge on the basic concepts of Errors and treatments of analytical data.
iii. Analysis of chemical data using various statistical tools.
iv. Describe various fundamentals of analytical techniques.

Course Outcome:

By the completion of course student will be able to

CO1. Apply various statistical tools for data analysis.
CO2. Formulate experimental data into appropriate statistical model.
CO3. Infer various analytical techniques and their working principles.
CO4. Explain various analytical techniques available for sample analysis in laboratories.

Course Content:

UNIT – I

Errors and data analysis: Introduction to analytical techniques, factors affecting choice of techniques. Basic definitions, Way of expressing accuracy, Errors: determinateand indeterminate and their minimization. Distribution of random errors and explanation using the normal distribution curve (Gaussian distribution). Propagation of determinant and indeterminate errors (problems), Statistical treatment of finite samples; standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance - comparison of two standard deviations, Comparison of two means, Comparison of an experimental mean and a true mean, rejection of a result - Q-test.

How to plot best fitting straight line; the least squares methods, standard deviations of the slope and intercept, correlation between two variables, detection limit, statistics of sampling - sample size, minimum sample size, and minimum number of samples. **[15 hrs]**

UNIT – II

Titrimetric analysis: Acid-base titrations in non-aqueous media - Introduction to aqueous acid – base titration, Role of non-aqueous solvent in acid-base titrations, differentiating ability of a solvent, levelling effect, selected solvents, titration curves, determining the equivalence point, typical applications - determination of carboxylic acids, phenols and amines.

Precipitation titrations: Principles of precipitation, common-ion effect, salt effect, Titration curves, feasibility of precipitation titrations, factors affecting shape - titrant and analyte concentration, completeness of the reaction, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the Fajan's methods, typical applications.

Complexometric titrations: Complex formation reactions, stability of complexes, role of metal ions and ligands, stepwise formation constants, chelating agents, EDTA - acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, EDTA titration curves, factors affecting the shape of titration curves - completeness of reaction, indicators for EDTA titrations - theory of common indicators, titration methods employing EDTA - direct, back and displacement titrations, indirect determinations. **[15 hrs]**

UNIT-III

Introduction to electro-analytical techniques: an over view of electrochemistry – electrochemical cells and reactions, electrode processes – faradaic and non-faradaic processes, brief description of electrical double layer and double-layer capacitance and charging current in electrochemical measurements, introduction to mass-transfer-controlled reactions, mechanism of mass transport, various currents in electrochemical cells – charging, residual current, migration, diffusion and convection currents, The current response to applied potential (in terms of Fermi and molecular orbitals)

Electrogravimetry,Coulometry, and Coulometric titrations, Amperometry, Polarography a voltammetric technique at a dropping mercury electrode (DME): Review of the principles of normal dc polarography, types of currents obtained at a DME,Ilkovic equation and its application, current-potential relation for a cathodic process – half-wave potential, basic aspects of electron transfer across the electrode–electrolyte interface, reversible and irreversible polarographic process, criteria for diffusion current and reversibility in polarography, electron transfer tests for the reversibility of a process – irreversible processes at a DME, a brief introduction to cyclic voltammeter. **[15 hrs]**

UNIT-IV

Chromatographic and Thermal methods: Basic theory of chromatography - Definition, principles of separation, classification of chromatographic techniques. General descriptions of column chromatography - frontal analysis, displacement analysis and elution analysis. General theory of column chromatography: characterizing a chromatogram - retention time, retention volume and baseline width.

Chromatographic resolution, capacity factor, column selectivity. Column efficiency – band broadening, rate theory and plate theory. Peak capacity, non-ideal behavior. Optimizing chromatographic separations using capacity factor, column selectivity and column efficiency - Van Demeter equation, Golay and Huber-Knox equations (only equations and terms involved).

Gas chromatography (GC): Principle, instrumentation - mobile phase, chromatographic columns, stationary phases, sample introduction, temperature control, and detectors for gas chromatography (naming of detectors) and applications.

High performance liquid chromatography (HPLC): Principle, instrumentation – columns (analytical and guard columns), examples for stationary phases, mobile phases used in HPLC, introduction to isocratic *vs* gradient elution process, detectors for HPLC (naming of detectors) and applications.

Thermal Methods

Thermogravimetric analysis - TGA, DTA and DSC, principle, instrumentation, and factors affecting the results, difference between TG and DTA, study of thermal stability of $CuSO_4.5H_2O$ and $Ca_2C_2O_4\,2H_2O$ by TGA. **[15 hrs]**

References:

1. Fundamental of Analytical Chemistry, 8thEdition, D.A. Skoog, D.M. West, Holler and Crouch, Saunders College Publishing, (New York).
2. Analytical Chemistry, 5thEdition,G.D. Christian, John Wiley & Sons, Inc, India,(2001).
3. Vogel's Textbook of Quantitative Chemical Analysis, 6thEdition Third Indian Reprint, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, Pearson Education Pvt. Ltd., New Delhi (2003).
4. Quantitative chemical analysis, 7thEdition, Daniel C. Harris, W.H. Freeman and company
5. Electrochemical methods - fundamentals and applications, 2ndEdition,Allen J. Bard, Larry R. Faulkner, John Wiley and Sons
6. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, (2000).
7. Analytical Chemistry Principles, John H. Kennedy, 2ndEdition, Saunders College Publishing, California, (1990).
8. Chromatographic methods, 5thEdition, A. Braithwaite and F J Smith, Kulwer Academic publishers.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM 0104	CO1	1	1	2	2	2			1					1
	CO2	2	1	2	2	2			1			1	1	1
	CO3	2	1	1	1	2			2			2	1	2
	CO4	2	2	2	2	3			2			2	3	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0105	COMPUTERS AND MATHEMATICS FOR CHEMISTRY	AECC/ HC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Understand the basics of computer and parts of computer components, software, hardware and operating systems.
ii. Learn few computer applications towards solving chemistry problems and also to make the student to use chemistry software programs.
iii. Find the importance of mathematics in chemistry and to solve the chemical problems.
iv. Apply mathematical concepts like vectors, algebra, differentiation and integrations to solve the quantum mechanics related problems.

Course Outcomes:

By the completion of course student will be able to

CO1: Use the computer and allied electronic devices in day to day life with basic knowledge of software and hardware.

CO2: Solve the chemistry related problems through Fortran/C programming and also able to use chemistry applications in research and pharma.

CO3: Apply the mathematical concepts like vectors and algebra to find solutions to the chemistry problems.

CO4: Implicate knowledge of differentiation and integration in solving the basic mathematics problems in chemistry.

Course Content:

Unit I: Introduction to Computing

History of development of computers, mainframe, mini, micro and supercomputer systems. Personal computers. General awareness of computer hardware, CPU, input and output devices, Storage devices, Printers, Bits and Bytes, Memory: Primary Memory, Secondary Memory., other peripheral devices, auxiliary storage devices.

Software - System software and application software.

Programming languages: machine language, assembly language and high level languages. Interpreter and compiler. Flow charts and Algorithms.

General awareness of operating systems: Disk operating system, Windows, MaCintosh, Linux. General awareness of Software packages and other scientific application packages.

8 hrs

Unit II: Computer Applications

The students will be taught to operate a PC and how to run standard programs and packages such as word, excel, power point. Applications and uses of common softwares in chemistry: Origin, sigma plot, Chemsketch/Chemdraw, MNova/MestreC etc and to solve chemistry problems. Cheminformatic tools:

SAS, SAAS, SSBI. Basic ideas on the use of Internet in Chemistry education, Literature review. Application to API bulk drugs,

Application of Fortran /C programming in problem solving (Problems will be taken preferably from physical chemistry for plotting first and second derivative curves, linear plots etc. Problems from chemical kinetics, polymer chemistry, analytical chemistry, electrochemistry, spectroscopy etc. will be solved.)

7 hrs

Unit III: Vectors and Matrix Algebra

Vectors: dot and cross products; scalar and vector triple products and their applications. Tensors and their applications.

Matrix Algebra: Review of different types of matrices (including Hermitian and skew Hermitian); matrix addition and multiplication; determinant of a square matrix, transpose, adjoint and inverse of a square matrix. **7 hrs**

Unit IV: Differentiation and Integrations

Calculus: Rule for differentiation; Chain rule for ($f(x)=U^n$, sinu, logu etc). Implicit differentiation and parametric differentiation and successive differentiation of order 2 (for explicit functions only).

Applications of differentiation: Derivative as a slope of the tangent, derivative as a rate measure velocity and acceleration. Increasing and decreasing functions-Maxima and minima.

Integrations: Basic rules-simple substitution-Method of partial fractions-Integration by parts. Define integral and application to areas of plane curves. Functions of several variables: partial derivatives; co-ordinate transformation from cartesian coordinates to spherical and cylindrical coordinates and vice-versa. Elementary differential equation: Variable separable, exact first order equations, linear and homogeneous equation. **8 hrs**

References:

1. Understanding Computers, Madric and Donevan, McGraw Hill.
2. Computers in Chemistry, K.V. Raman, Tata McGraw Hill (1993).
3. Personal Computers in Chemistry, P. Lykose, John Wiley and Sons, New York (1981).
4. Computers and their applications to Chemistry, 2nd Edition, Ramesh Kumari, Alpha Science.
5. Computers in Chemistry, Biggs Pete, Oxford University Press (2000).
6. Using Artificial Intelligence in Chemistry and Biology: A Practical Guide, Cartwright Hugh, CRC Press, (2008).
7. Mathematical Computer Programs for Physical Chemistry, Cropper William H, Springer.
8. Chemistry by Computer: An Overview of the Applications of Computers in Chemistry, Stephen Wilson, Plenum Pub Corp (1986).
9. Computer Software Applications in Chemistry, 2nd Edition, Peter C. Jurs, John Wiley &Sons.
10. Mathematical Preparation for physical chemistry, F. Daniells, Tata McGraw Hill Inc., US (1959).
11. Mathematics for chemists, D. M. Hirst, Chemical Publishing Company Incorporated, New York (1979).
12. Mathematics for chemists, P. G. Francis, Springer (2011).
13. Basic Mathematics for chemists, P. Jebutt, Wiley-Blackwell (1994).
14. Calculus and analytic geometry, 9th Edition, C. G. Thomas, R. L. Finney, Addison-Wesley Publishing Company, lnc (1996).
15. Short Course in differential equations, Rainvilles and Bedient, IBH publishers (1968).
16. Mathematics for chemistry, G. Doggett and B. T. Sutcliffe Longmann publishers (1995).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0105	CO1	3	3		2	2		1			3	1		2
	CO2	3	3		2	2		1			2	1		
	CO3	3	3		1	1		1			2	1		1
	CO4	3	3		2	1		1			2	1		1

SEMESTER-I: SOFT CORE (SC)/DSEC*

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS101	**INTRODUCTION TO NANO-SCIENCE AND NANO-TECHNOLOGY**	DSEC*/ SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Introduction to nanotechnology.
ii. Classification of nanostructures and the methods of synthesizing.
iii. The various Nanomaterials characterization techniques nanomaterials and Carbon nanomaterials.
iv. The applications of nanomaterials in nanoelectronics and Biochemical sensor.

Course Outcomes:

By the completion of course student will be able to:

CO1. Explain the methods of synthesis of nanomaterials with properties and applications.

CO2. Categorize the Types of Nanostructures includes carbon nanomaterials and discuss the preparation, properties and applications.

CO3. Describe the various types of nanomaterials characterization techniques like imaging techniques and Spectroscopic techniques.

CO4. Apply the acquired theoretical knowledge to classify as nanocatalysts, chemical sensors, biosensors, drug delivery, Biochemical sensor, Biophysical sensor and nano electronics.

Course Content:

UNIT-I

Background to Nanotechnology: Atom, molecules and nanoscale materials, Electrons in nanostructures, Quantum size effects, Density of states, Size effects on surface energy, surface area, optical, electrical, magnetic, thermal properties. Emergence of Nanotechnology – Challenges in Nanotechnology.

Synthesis issues of nanomaterials: Nucleation-Growth mechanism of nanomaterials, Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches-self-assembly process-grain boundary volume in nanocrystals-defects in nanocrystals-surface effects on the properties. Stability of nanomaterials, Synthesis approaches, Physical methods, Chemical methods, Chemical interactions at nanoparticle surfaces, Functionalization of nanostructures, Self-assembly of nanostructures, Nano Lithographic techniques, Electrodeposition. **[8 hrs]**

UNIT-II

Types of Nanostructures: Definition of a Nano system – Types of Nanocrystals-One Dimensional (1D)-Two Dimensional (2D) –Three Dimensional (3D) nanostructured materials – Quantum dots – Quantum wire, Quantum wells, Core/Shell structures. Their electronic properties, Physical and chemical methods for preparation of nanomaterials

Carbon nanomaterials:

Fullerenes: Structure and reactivity of fullerenes, preparation of fullerenes and Functionalization of fullerenes, chemistry of fullerenes, physical properties of fullerenes, Applications – solar cells, medicine, superconductors,

CNT: CNT formation mechanism, Electronic properties of SWNT, DWNT, MWNTs, CNT growth techniques, structure and properties (electrical conduction, magnetic, magnetoresistance, mechanical, thermal), Nanocomposites of CNTs, Applications,

Graphene, Electronic properties of graphene, Diarc fermions in graphene, Anamolous Quantum Hall Effect, Ambipolar conductivity, optical, mechanical properties of graphene, Experimental detection of number of layers, Preparation of graphene: Micromechanical, chemical methods, physical methods, Functionalization, Applications

Nanodiamond and Diamond like carbon: Structure, synthesis, Surface structures, reactivities of nanodiamond, Phase diagram of DLC, Effects on properties with DLC composition, device applications

[7 hrs]

UNIT-III

Nanomaterials characterization techniques:

Imaging techniques: Scanning Electron Microscope (SEM) – Field Emission scanning Electron microscope(FESEM)-Atomic force microscopy (AFM), Chemical force microscopy (CFM), optical tweezers for force measurements, scanning tunneling microscopy (STM), scanning near field optical microscopy (SNOM) – Transmission Electron Microscopy (TEM).

Raman Scattering –MicroRaman-tipenhanced Raman-Surface Enhanced Raman scattering (SERS)– Photoluminescence (PL)– Cathodeluminescence (CL). **[8 hrs]**

UNIT-IV

Applications of Nanomaterials: Molecular electronics and nanoelectronics – Quantum electronic devices - CNT based transistor and Field Emission Display – Nano magnetics, nanophotonics nanospintronics, Biological applications - Inorganic nanoprobes in Quantum dots, Inorganic nanosystems/biomolecules interface toward nanotechnologies, biophysicochemical interaction at the nano/bio interface, Biochemical sensor - Membrane based water purification. Renewable energy (nano solar cells), Photoelectrochemical cells, coloured glasses, (gold and silver ruby glasses), Nanocatalysts, chemical sensors, biosensors, SAM, electrical and electronics,(RAM). Chemical and photocatalytic applications. Drug delivery targeting and

medical applications, micro-electrochemical machines (MEMS).

[7 hrs]

References:

1. Nanotechnology: Basic science and Emerging technologies,1st Edition,M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Overseas Press India Pvt Ltd, New Delhi, (2005).
2. The Chemistry of Nanomaterials: Synthesis, properties and applications, C.N.R. Rao, A.Muller, A.K.Cheetham (Eds), Wiley VCH Verlag Gmbh&Co, Weinheim, (2004).
3. Nanoscale Materials Science, Kenneth J. Klabunde (Eds), John Wiley & Sons, Inc, (2001).
4. Nanofabrication towards biomedical applications, C.S.S.R. Kumar, J.Hormes, C.Leuschner, Wiley –VCH Verlag GmbH & Co, Weinheim, (2004).
5. Nano Electronics and information Technology,W. Rainer, Wiley, (2003).
6. Nano systems, K.E. Drexler, Wiley, (1992).
7. Nanostructures and Nanomaterials: Synthesis, properties and applications,G. Cao, Imperical College Press, (2004).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS101	CO1	2	2	1	2	1	1				1	3	1	1
	CO2	2	2	2	2	1	1				1	3	1	1
	CO3	2	1	2	1	1	1				1	3	2	2
	CO4	2	1	2	2	2	1				1	3	2	3

Course Code	Course Title	DSEC/	L	T	P	C	Hrs/Week
M21SMS102	HETEROCYCLIC CHEMISTRY AND CHEMISTRY OF BIO-MOLECULES	DSEC/SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. To use different heteroatoms in the ring and uses in drug production.
ii. Provides the synthesis of five, six and seven membered monocycles and the fused heterocycles.
iii. It also provides assembly of amino acids, peptide and protein structures.
iv. Discuss the topics include chemical and biochemical strategies used to elucidate natural product pathways.

Course Outcomes:

By the completion of course students will be able to

CO1. Explain the fundamental concepts of reactivity and aromaticity of various heterocyclic compounds.

CO2. Illustrate the synthesis of various heterocyclic compounds.

CO3. Analyze the different types of heterocyclic compounds.

CO4. Outline the synthesis of prostaglandins-E1, E2 and vitamins.

CO5. Apply the biological importance of DNA, RNA and classify the different types of proteins.

Course Content:

UNIT-1

Synthesis and reactivity of pyrrole, furan and thiophene. Basicity of pyrrole and pyridine.

Small ring heterocycles-Three and four membered heterocycles- synthesis and reactions of aziridines, oxiranes, oxitanes, thietane. Five membered heterocycles containing two/three heteroatoms- synthesis and reactions of imidazoles, thiazoles. Synthesis and reactions of benzo pyrrole, benzo furans and benzo thiophene. **[7 hrs]**

UNIT-II

Six membered heterocycles with one heteroatom: Synthesis and reactions of pyrylium, pyridinium and thiopyrylium salts. Six membered heterocycles with two and more heteroatoms-Synthesis and reactions of diazine (pyrazine, pyridazine, oxazine, thiazine) & triazine (1, 2, 3, and 1, 2, 4). Seven membered heterocycles –Synthesis,and reactions of azepine, oxepine & thiepine. **[8 hrs]**

UNIT-III

Introduction of biomolecules: Examples of biomolecules and building blocks of biopolymers. **Nucleic Acids**-Purine and pyrimidine bases. Structure and synthesis of nucleosides and nucleotides. (DCC, phosphor tri ester approach Properties of nucleic acids in solution. Base pairing, forces stabilizing nucleic acid structure. Methods used in nucleic acid separation and characterization. Hydrolysis of nucleic acids by acid and base. Enzymatic hydrolysis, Nuclease specificity and restriction endonucleases.

Prostaglandins-General study, nomenclature, classification, structure and biological role of PGE1, PGE2 and PGE3. **[8 hrs]**

UNIT-IV

Biochemical mechanisms

Introduction. The mechanistic role of the following in living systems.

1. Thiamine pyrophosphate (TPP) in decarboxylation of α-ketoacids and in the formation of α-ketols.
2. Pyridoxal phosphate (PLP) in transamination, decarboxylation, dealdolisation and elimination reactions of amino acids.
3. Lipoic acid in the transfer of acyl group reactions.
4. Coenzyme A (CoASH) in the transfer of acyl group.
5. Tetrahydrofolic acid (H4F) in one-carbon transfer reactions.
6. Vitamin B12 coenzymes in molecular rearrangement reactions and in the synthesis of methionine and methane.
7. Nicotinamide and Flavin coenzymes in biological redox reactions. **[7hrs]**

References:

1. Heterocyclic chemistry, Joule & Smith, Van Nostrand.
2. Heterocyclic chemistry,R. K. Bansal, Wiley Ed.
3. Principals of modern heterocyclic chemistry,L. A. Paquitte.
4. The structure and reactions of heterocyclic compounds,M. H. Palamer.
5. Advances in Heterocyclic chemistry,A. R. Katritzky.
6. Biochemistry, J. David Rawn, Neil Pattuson publishers, North Carolina, USA (1989).
7. Organic Chemistry,6th Edition,Vol I and Vol II, I. L. Finar, ELBS & Longman, London, (1975).
8. Introduction to Lipids, D. Chapman, McGraw-Hill, (1969).
9. Advanced general Organic Chemistry, S. K. Ghosh, DK and Allied publishers (UBS), Calcutta, (1998).
10. Textbook of Biochemistry, E. S. West, W. R. Todd, H. S. Mason & J. T. Van Bugen, 4th Edn. Amerind publishing co. (New Delhi), (1974).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM S102	CO1	3	2	2	1	2				1	2	3	4	3
	CO2	3	3	3	4	3	1			1	2	3	4	3
	CO3	3	3	3	2	3				1	2	3	4	3
	CO4	3	2	3	1	3	3			1	2	3	3	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS103	SURFACE, INTERFACES AND CATALYSIS	SC	2	0	0	2	2

Course Objective:

This course aims to provide the student to

i. Correlate the topics like Surface phenomena of solids, solid-liquid interfaces, Homogenous and Heterogeneous Catalysis and Instrumental methods of catalyst characterization.
ii. Illustrate Homogenous and Heterogeneous Catalysis and Instrumental methods of catalyst characterization. Describe the *lock-and-key* and *induced-fit* models of enzyme action.
iii. Explain the function of a catalyst in terms of reaction mechanisms and potential energy diagrams
iv. Gain the Knowledge of Catalyst characteristics, Mechanism of catalytic reactions and design of catalytic Reactor.

Course Outcomes:

By the completion of course student will be able to

CO1. Use modern methods when planning strategies for synthesis of new substances and characterization of products.
CO2. Depth knowledge about chemical reactions with a focus on principles for effective synthesis strategies, stereo selectivity, catalysis,
CO3. Predicting the chemical reaction using efficient computational models can be used to develop high-throughput screening techniques.
CO4. Research-based in-depth understanding in the field of design and production (synthesis) of complex molecules.

Course Content:

UNIT – I

Surface phenomena: Surface forces, Structure of clean surfaces; Solid surfaces: External and internal surfaces; Bulk and surface structure of FCC, BCC and HCP metals, Notation of surface structure; Structure of adsorbate layers; Stepped surfaces; Surface relaxation and reconstruction of surfaces; homogeneous and heterogeneous surfaces. **[7 hrs]**

UNIT-II

Types of interfaces. Liquid surfaces: Microscopic picture of interfaces; curved interfaces; Young - Laplace and Kelvin equations; capillary condensation; surface tension; measuring surface tension.

Solid-liquid interfaces: Contact angle and wetting, Gibbs adsorption isotherm. Solid-gas interfaces: Types of adsorption; Adsorption isotherms – Langmuir, Tempkin and BET. Determination of surface area of adsorbents; temperature dependence of adsorption isotherms. **[8 hrs]**

UNIT – III

Fundamentals of Homogenous and Heterogeneous Catalysis: Mechanism, Adsorption isotherms, surface area, pore size and acid strength measurements; Porous solids; Catalysis by metals, semiconductors and solid acids; Supported metal catalysts; Catalyst preparation, deactivation and regeneration. Model catalysts: Ammonia synthesis; Hydrogenation of carbon monoxide; Hydrocarbon conversion. Some important heterogeneous catalytic processes. **[8 hrs]**

UNIT – IV

Instrumental methods of catalyst characterization: Diffraction techniques – X-Ray, Neutron, electron, surface area and thermal methods; spectroscopic, ionization techniques, and microscopic techniques. Determination of the extent and rates of adsorption and desorption. **[7 hrs]**

References:

1. Physics at Surfaces, A. Zangwill, Cambridge Univ. Press, (1988).
2. Catalytic Chemistry, B. Gates, Wiley, 1992.
3. Physical Chemistry of Surfaces, A.W. Adamson, A.P. Gast, Wiley, (1997).
4. Principles and Practice of Heterogeneous Catalysis, J. M. Thomas and W.J. Thomas, Wiley-VCH, (1997).
5. Surface Science: Foundations of Catalysis and Nanoscience, K.W. Kolasinski, Wiley, (2002).
6. Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age, (2008).
7. Introduction to Surface Chemistry and Catalysis, G.A. Somorjai, Y. Li, Wiley, (2010).
8. Physical chemistry of surfaces, Arthur W. Adamson,(1990).
9. Chemical kinetics and catalysis, R.I. Masel, Wiley-Interscience, (2001).
10. The chemical physics of surfaces, Roy S. Morrison, S. Roy, (1990).
11. An introduction to chemisorption and catalysis by metals, R.P.H. Gasser, (1985).
12. Modern techniques of surface science, D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, (1994).
13. Introduction to Scanning Tunneling Microscopy, C. J. Chen, Oxford University Press, New York, (1993).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3

M21SM S103	**CO1**	3	2	1	1	2	2	2	2	1	2	2	1	1
	CO2	2	2	2	2	3	2	1	2	2	1	2	2	2
	CO3	3	2	2	2	3	2	2	2	3	3	2	2	2
	CO4	3	3	3	2	3	2	1	3	2	2	3	2	1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS104	ADVANCED INSTRUMENTAL METHODS OF ANALYSIS	DSEC*/SC	2	0	0	2	2

Course Objectives:

This course aims to provide students

i. To get knowledge on concepts of absorption spectroscopy, emission spectroscopy, voltammetry, thermogravimetry, introduction to NMR.
ii. Understanding on the principles and applications of advanced instrumental techniques.
iii. Introduce the spectroscopic techniques importance in analysis of chemical compounds.
iv. Advances in various analytical techniques.

Course Outcomes:

By the completion of course student will be able to

CO1. Apply the knowledge gained on advanced instrumentation in interpretation of analytical data.
CO2. Choose the advanced characterization techniques required for complex material analysis.
CO3. Analyze the surface and interfacial processes using advanced characterization tools.
CO4. Evaluate the need of instrumental analysis in multidisciplinary research and industrial processes.

Course Content:

UNIT-I

Absorption Spectroscopy: absorption, emission, fluorescence phenomenon, principles and differences, Flame AAS, Instrumentation, different types of nebulizers, Non flame techniques, GAAS, electrothermal vapourisers, graphite furnace, cold vapor AAS, radiation sources, HCL, EDL, TGL etc. detectors, photo emissive cells, PMT, photodiodes, Interferences, spectral, chemical, matrix, background absorption, correction methods, deuterium arc, zeeman effect, Smith-Hieftje methos, single beam and double beam instruments, evaluation procedures, applications of AAS. **[8 hrs]**

UNIT-II

Atomic Emission Spectroscopy: Emission-principle, inductively coupled plasma optical emission spectrometry, theory, ICP characteristics, sample introduction methods, tourch configuration and view modes, analytical performance. Merits and limitations of AES over AAS, Detection limit, application to elemental analysis, Microwave induced plasma systems in atomic spectrometry, principal processes and applications. **[7 hrs]**

UNIT-III

Electroanalytical Techniques: Electrode Potential, Currents in Electrochemical cells, Potentiometric titrations. Electrogravimetry-faraday's laws of electrolysis, Coulometry, Coulometric titrations. Voltammetry- principle, DME-advantages, limitations, Hydrodynamic Voltammetry, Cyclic voltammetry-principle, conditions for reversible, quasi reversible and irreversible reactions Anodic stripping voltammetry-principle and applications, Polarography, Pulse polarography, Amperometry-titrations, different titration curves, applications, numerical problems on all these techniques. **[7 hrs]**

UNIT-IV

Thermal Methods of Analysis: Principle, methodology and applications: thermogravimetric and differential thermal analysis, differential scanning calorimetry; Thermo-mechanical and dynamic mechanical analysis; thermometric titrations. Thermal stability of polymers, applications, decomposition patterns, decomposition reactions-examples. **[7 hrs]**

References:

1. Analytical Chemistry, Gary D Christian, 5thEdition, John – Wiley and Sons Inc., (1994)
2. Fundamentals of Analytical Chemistry,7thEdition, D. A. Skoog, D. M. West and F. J. Holler, Saunders College Publishing (1996).
3. Instrumental methods of Analysis, H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Set, CBS Publishers (1996).
4. Instrumental methods of Chemical Analysis, G. W. Ewing, 5th edition, McGraw-Hill, New York, (1988).
5. Electrochemical methods, 2nd Edition, A.J. Bard & l. R. Faulkner, Wiley, New York, (2000).
6. Vogel's text book of Quantitative Chemical analysis, 5th edition, Jeffery et. al., ELBS/Longman, (1989).
7. Encyclopedia of Analytical Chemistry, R.A. Meyers Vol. 1 – 15, John Wiley, (2000).
8. Fundamentals of Instrumental Analysis, 8thEdition, Skoog, D. M. West and F. J. Holler, Saunders College Publishing (2004).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS104	CO1	2	1	1	2	3	1			1	2	2	2	3
	CO2	1	2	1	3	3	1			1	2	1	1	3
	CO3	2	2	2	1	2	1			2	2	1	3	2
	CO4	2	3	2	3	3	2			2	2	2	2	1

SEMESTER-I: PRACTICALS

Course Code	Course Title	TYPE	L	T	P	C	Hrs/Week
M21SM0106	ORGANIC CHEMISTRY-I PRACTICAL	HC	0	0	2	2	4

Course Objectives:

The practical course on organic chemistry intends to

i. Develop scientific skills in qualitative and preparative techniques.
ii. Analyze and conclude from the systematically recorded observations.
iii. Apply the experimental knowledge for analytical reasoning and rational improvisation.
iv. Evaluate the scientific data and transform into tangible outcomes.

Course Outcomes:

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

CO1. Develop proficiency to carry out conventional organic synthesis, reactions at inert atmosphere, low temperature, reflux conditions and develop a basic understanding of the reactivity of functional groups

CO2. Acquire skills to perform laboratory techniques such as distillation, re-crystallization, vacuum filtration, solvent extraction and chromatography

CO3. Predict the mechanism of organic reactions, and characterize the molecules by physical methods such as Melting point or Boiling point.

CO4. Evaluate the spectral data to determine the identity and purity of the products.

Course Content:

1. Cannizarro reaction: Benzaldehyde
2. Fries rearrangement: Phenyl acetate
3. Friedel-Crafts reaction: Benzene and Acetyl chloride
4. Sandmeyer reaction: 4-Chlorotoluene from 4-toluidine
5. Pechmann reaction: Resorcinol and ethylacetoacetate
6. Oxidation of cyclohexanol
7. Preparation of S- benzylisothiuronium chloride
8. Synthesis of p-iodonitrobenzene
9. Synthesis of N-Phenyl-2,4-dinitroaniline
10. Synthesis of 2,4,6-tribromoaniline
11. Synthesis of 2,4-dichlorophenoxyacetic acid
12. 2,4-Dinitrophenylhydrazine from chloronitrobenzene

13. Anthranilic acid from phthalic acid
14. Benzanilide from benzophenone
15. Benzilic acid from benzoin
16. Synthesis of acridone
17. Synthesis of hydantoin
18. Synthesis of 2-aryl benzimidazole
19. Synthesis of *t*-alcohol by Barbier reaction
20. Synthesis of tetralin
21. Asymmetric reductive amination
22. Asymmetric aldol reaction

References:

1. Experimental Organic Chemistry: A Mini and Macroscale Approach, Fifth Edition, John C. Gilbert, Stephen F.Martin, Brooks/Cole, Boston, (2011).
2. Microscale Organic Laboratory, 5thEdition, Dana W. Mayo, Ronald M. Pike, David C. Forbes, Wiley, New Jersey, (2011).
3. Modern Organic Synthesis in the Laboratory, 1stEdition, Jie Jack Li, Chris Limberakis, Derek A. Pflum, Oxford University Press, (2007).
4. Vogel's Text Book of Practical Organic Chemistry, 5thEdition, Brian S. Furniss, Antony J. Hannaford, Peter W. G. Smith, Austin R. Tatchell, Longman Scientific and Technical, (1989).

Mapping of Course Outcomes with Programme Outcomes

Course Code	**POS/ COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21SM S0106	CO1	3	2	3	1	2	3	2			1	2	3	2
	CO2	2	2	2	3	2	2	2			1	3	2	3
	CO3	2	2	3	1	3	2	3			1	3	3	2
	CO4	3	2	3	1	2	1	2			1	2	2	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0107	PHYSICAL CHEMISTRY – I PRACTICAL	HC	0	0	2	2	4

Course Objectives:

This course aims to provide the student to

1. Knowledge on various analytical techniques for the examination of analyte
2. Apply Skills in qualitative and preparative techniques.
3. Observe and assess the role of electrodes
4. Compare various factors that influence experimental values.

Course outcomes

By the completion of course student will be able to

1. Operate instruments during conduction of experiments.
2. Analyze and interpret the experimental data.
3. Demonstrate experimental skills in laboratories.
4. Identify causes for erratic results and achieve better results.

Course Content:

pH Experiments

1. Calibration of pH meter and pKa measurements

2. Determination of pKa of orthophosphoric acid by pH & Potentiometric methods.

Conductivity experiments

1. To determine the equivalence conductance of strong electrolytes (CH_3COONa, $NaNO_3$, KNO3) at several concentrations and hence verify the Onsagar equation

2. To determine the equivalent conductance of electrolytes at infinite dilution using Kohlrausch law.

Viscosity experiments

1. Determination of the molecular weight of a polymer material by viscosity measurements (polyvinyl alcohol).

Spectrophotometric experiments

1. Verification of Beer's law and calculation of molar extinction coefficient for $CuSO_4$system.

2. Spectrophotometric titration of $FeSO_4$ against $K_2Cr_2O_7$.

3. To determine the concentration of liquids in a binary mixture containing $K_2Cr_2O_7$ and $KMnO_4$ using spectrophotometer.

Potentiometric experiments

1. To determine pH of buffer solutions potentiometrically.

Surface chemistry

1. Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal
2. Adsorption of acetic acid on charcoal and silica gel.

Kinetics

1. Study of Kinetics of hydrolysis of esters using HCl/ H_2SO_4 at two different temperatures, determination of rate constants and energy of activation.
2. To study the effect of addition of electrolyte (KCl) on the rate of reaction between potassium persulphate and potassium iodide **(Equal concentration)**.

Reference Books:

1. Practical Physical Chemistry, A.J. Findlay.
2. Experimental Physical Chemistry, F. Daniels et al.
3. Experiments in Physical Chemistry, Yadav, Geol Publishing House.
4. Experiments in Physical Chemistry, Palmer.
4. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata Mc Graw Hill.

Mapping of Course Outcomes with programme Outcomes

Course .Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0107	CO1	1	2	1	2	1	2	1	2	2	2	2	2	2
	CO2	2	1	2	2	2	1	1	2	1	2	1	2	1
	CO3	2	2	2	1	1	2	1	1	1	2	2	1	2
	CO4	2	2	2	2	2	2	1	2	1	2	2	1	1

SEMESTER-II

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0201	INORGANIC CHEMISTRY –II	HC	3	1	0	4	5

Course Objectives:

This course aims to provide the student to

i. Correlate topics in coordination chemistry like metal – ligand equilibria, electronic spectra and magnetic properties of metal complexes.
ii. Illustrate the MOT of different types of bonding in metal complexes
iii. Conclude the varies types of inorganic reaction, mechanism and there application
iv. Design the students to have a dynamic interaction to adapt to changes in life

Course Outcomes:

By the completion of course student will be able to

CO1. Apply the Knowledge of d and f-block elements in explaining, interpreting and examining bonding, structure reactivity of complexes

CO2. Illustrate the electronic transitions and magnetic behavior and magnetic susceptibility of the complexes determined by new methods.

CO3. Acquire the detailed knowledge on substation, elimination, oxidation and reduction, photochemical reactions.

CO4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

Course Content:

UNIT – I

Metal-Ligand equilibria in solution: Step-wise and overall formation constant and their relationship, trends in step-wise constant, kinetic and thermodynamic stability of metal complexes, factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand, chelate effect, macrocyclic effect trans effect (sigma and pi bonding effect) and their thermodynamic origin. Determination of binary formation constant by pH metry, spectrophotometry, polarography and ion exchange methods. Introduction to redox chemistry of complexes. Redox chemistry and analytical applications.

Structure and bonding - Structure and bonding in hydride, dihydrogen, dioxygen, isocyanide, CO, NO, N_2 and tertiary phosphine complexes of transition metals. **[15 hrs]**

UNIT- II

Metal- ligand bonding: Stereoisomerism- coordination numbers 3 to 8. Optical isomerism(ORD and CD) Crystal field theory, salient features, spectrochemical series, splitting of d-orbitals in tetragonal, square planar, trigonal bipyramidal and square-pyramidal geometry, applications of CFT- colours of transition metal complexes, magnetic properties of octahedral complex, distortion of octahedral complex, Jahn-Teller distortions CFSE and their uses, factors affecting CFSE, limitations of CFT, experimental evidence for metal-ligand covalent bonding in complexes, nephelauxetic effect, Ligand Field Theory, MO theory: Square planar complex tetrahedral and octahedral complexes (including sigma and singma and π- interactions), angular overlap model. Redox chemistry and analytical applications. **[15 hrs]**

UNIT– III

Electronic spectra of coordination compounds:Spectroscopic ground states, selection rules, term symbols for d^n ions, Spin-Orbit coupling, Racah parameters, Orgel, Correlation and Tanaube-Sugano diagrams, spectra of 3d metal-aqua complexes of trivalent V, Cr, divalent Mn, Co and Ni, $CoCl_4^{2-}$, calculation of Dq, B and β parameters, Jahn-Teller distortions and spectra, CT spectra. Spectral properties of Lanthanide and Actinide metal complexes. Photochemical reactions of transition metals complexes: Basic photochemical processes, Kasha's rule, quantum yield, Jabolnskii diagrams, photo substitution reactions, photo-redox reactions, ligand photoreactions, and metal complexes as photosensitizers. **[15 hrs]**

UNIT– IV

Magnetic properties of coordination compounds: Origin and Types of magnetic behaviour, magnetic susceptibility and its determination- Gouy, Faraday, VSM method Quinke's method, Evans NMR method, Magnetic titrations. Curie's law and Curie-Weiss law, Diamagnetic correction, orbital contribution, spin-orbital coupling, ferro and antiferromagnetic coupling, spin crossover. Magnetic properties of axially symmetric crystal field, high spin/low spin equilibrium, Magnetic properties of Lanthanide and Actinide metal complexes.

Higher coordination numbers, symbiosis, Introduction to ligand substitution reactions: Inert and labile compounds, mechanism of substitutions – reaction pathways, Linear free energy relationships, selected examples, Introduction to redox chemistry of complexes. **[15 hrs]**

References:

1. Basic Inorganic Chemistry, 6thEdition, F. A. Cotton, G. Wilkinson and P. L. Gaus; John Wiley and sons. Inc, (1999).
2. Chemistry of elements, N. N. Greenwood and A. E. Earnshaw, Butterworth Heinemann (1997).
3. Inorganic Chemistry,4thEdition; J. E. Huheey, E. A. Keiter and R. L. Keiter, Addison; Wesley (1993).
4. Inorganic Chemistry, 2nd Edition, D. F. Shriver, P. W. Atkins and C. H. Langford, ELBS; Oxford University Press, (1994).
5. Inorganic Electronic spectroscopy, A. B. P. Lever, Elsevier. (1968).

6. Magnetochemistry, R.L. Carlin, Springer Verlag.
7. Electronic Absorption Spectroscopy and related Techniques, D. N. Sathyanarayana, University Press (2001).
8. Inorganic Chemistry A Unified Approach, 2nd Edition, W. W. Porterfield, Elsevier (2005).
9. Textbook of inorganic chemistry, G. S. Sodhi, Viva books Pvt. Ltd (2006).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0201	CO1	3	1		2	1	1		2		2	1	2	
	CO2	3	3	2	2	1	1	1	2	1	2	2	2	2
	CO3	3	2	1	2		2		2	2	2	1	1	2
	CO4	2	3	2	1	2	2	2	2	2	3	2	1	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0202	ORGANIC CHEMISTRY – II	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. It deals with the relationships between Organic chemical structures and their reactivity.
ii. Focuses on studies of reaction mechanisms in addition, elimination, substitution reactions
iii. To bring the importance of mechanism in C-C and C-N containing organic compounds and rearrangement reactions
iv. To identify the suitable regent for organic reaction and to determine their reaction mechanisms.

Course Outcomes:

By the completion of course student will be able to

CO1. Analyze functional groups effect on electron density, properties and reactivity in organic compound.

CO2. Illustrate the reaction mechanical aspects in organic synthesis.

CO3. Explain the reaction mechanism involved in organic named reactions with respect to C-C and C-N bonding

CO4. Identify and inspect the mechanisms involved in named reactions, reagents, oxidations and reductions in solving chemistry problems.

Course Content:

UNIT-I

Addition to carbon-heteroatom multiple bonds: Mechanism of metal hydride reduction ($LiAlH_4$, $NaBH_4$, $NaBH(OAc)_3$, $NaBH_3(CN)$) of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents and organolithium reagents to carbonyl compounds and unsaturated carbonyl Compounds. Hydrolysis of nitriles and addition of amines isocyanates Wittig, Mannich and Stobbe reactions.

Addition to carbon-carbon multiple bonds: mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. Regio, stereo- and chemoselectivities. Orientation and reactivity. Addition to cyclopropane ring. Michael reaction.

Self-Study: Vilsmeier-Haack reaction, Gatterman reaction, Gattermann-Koch reaction and Hoesh reaction. Von Richter reaction, Sommelet-Hauser and Smiles rearrangements, Addition of alkenes and/or alkynes to alkenes and/or alkynes. Ene synthesis. **[15 hrs]**

UNIT-II

Molecular Rearrangements: Molecular rearrangements: Definition and classification. Molecular rearrangements involving i) electron deficient carbon: Wagner- Meerwein, Pinacol-Pinacolone, and Wolf rearrangement. ii) electron deficient Nitrogen: Hofmann, Lossen, Curtius, Schmidt rearrangements iii) electron deficient Oxygen: Baeyer-Villiger oxidation. iv) Base catalysed rearrangements: Aldol condensation, Benzoin, Knoevengel, Sommlett-Hauser and Smiles rearrangement.

Multi-component Reactions: Studies on the mechanistic aspects and use of the following reactions in organic synthesis: Passerini-Ugi; Hantsch; Biginelli; Doebner-Miller; Ritter; Jacobson; Betti; Robinson-Schopf; Barbier; Baylis-Hilmann; Ivanov and Suzuki coupling reaction. **[15 hrs]**

UNIT-III

C-C and C-N bond forming reactions: Darzen's reaction, Use of acetylides in C-C bond formation reactions. Acid-catalyzed self-condensation of olefins, Prins reaction, Shapiro reaction, Dieckmann cyclization, Robinson annulations, Hofmann-Loeffler-Freytag reaction. Hofmann-Martius reaction. Acyloin condensation. Houben-Hoesch reaction. Stork-enamine synthesis. Meyer synthesis. Use of nucleophilic nitrogen and electrophilic carbon (NH_3, amines and nitrite as nucleophiles in substitution, NH_3 and amines in addition to ketones and aldehydes) and electrophilic nitrogen and nucleophilic carbon (nitration, nitrosation) for the bond formation reactions.

***Self-Study**:* Chichibabin reaction, Skraup synthesis, Mitsunobu reaction, N-Nitroaromatic amine rearrangement, Fisher-Hepp reaction, Japp-Klingemann reaction. **[15 hrs]**

UNIT-IV

Reagents in organic synthesis: Use of the following in organic synthesis and functional group tansformations. Aluminium iso-propoxide, NBS, LDA, DCC, DDQ, 1,3-Dithiane (reactivity and umpolung), Sulphur ylides, PPA, Yamaguchi reagent. Woodward and Prevost hydroxylation

Oxidations-I: Cr (VI) oxidants, Mn (VII) oxidants, OsO_4- and co-oxidants SeO_2, Pb $(OAc)_4$, IBX and related reagents.

Oxidations-II: ozone, peroxides (H_2O_2, t-BuOOH, dibenzoylperoxide) and per acids (Preparation, properties and applications of CF_3COOOH, m-CPBA, monoperphthalic acid) as oxidizing agents.

Reductions: Complex metal hydrides, dissolving metal reductions (including Birch, Benkeser, Clemmensen reductions), diimide reduction, catalytic hydrogenation (homogeneous and heterogeneous), Hydrogenation of double and triple bonds, hydrogenation of aromatic rings.McMurry reaction. Pummer, Willgerdo.

[15 hrs]

Self-Study: Corey-Chaykovsky reagent, Raney-Nickel, diazomethane, TMS-chloride, HIO_4, Ag_2O, DMSO, Dess-Martin oxidation. Wolf-Kishner reduction Corey-Bakshi-Shibata and Tishchenko reactions, Junjappa-Ila hetero aromatic annulation reaction.

References:

1. Advanced Organic Chemistry, Reactions, Mechanism and Structure, Jerry March, John Wiley (2008).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum (1990).
3. A Guide Book to Mechanism of Organic Chemistry, Peter Sykes, Longman (2000).
4. Structure and Mechanism of Organic Chemistry, C. K. Ingold, Cornell University Press.
5. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall (1998).
6. Modern Organic Reactions, H. O. House, Benjamin (1972).
7. Principles of Organic Synthesis, ROC Norman and J. M. Coxon, Blackie Academic and Professional (1996).

Mapping of Course Outcomes with programme Outcomes.

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0202	CO1	3	2		2	2	2			1	1	3	2	1
	CO2	3	3	1	2	2	2			1	1	3	2	2
	CO3	3	3	1	2	2	1			1	1	3	2	2
	CO4	2	2	1	2	2	2			1	1	3	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0203	PHYSICAL CHEMISTRY- II	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Provides students to enlighten the knowledge on Quantum chemistry,
ii. To give insights on molecular symmetry and group theory.
iii. Focuses on representation and applications of various spectroscopic techniques like microwave, vibrational, electronic, Raman, EPR and NMR.
iv. Understand the importance of physical Principles in spectroscopy and bonding.

Course Outcomes:

After successful completion of this course, the student will be able to:

CO1. Apply the fundamental knowledge of quantum mechanical processes involved in atoms and molecules, and interpret the symmetry, spectroscopic and electronic properties of matter

CO2. Devise the character tables to identify the allowed vibrational transitions and analyze the importance of symmetry in chemical bonding

CO3. Analyze the rotational and vibrational spectra to evaluate the bond strength, bond length and the amount of isotopes mixtures.

CO4. Interpret various spectroscopic data of materials obtained using advanced analytical tools by utilizing the theoretical basis and predict the structure of chemical compounds.

Course Content:

UNIT – I

Quantum Chemistry: Planck's concept of quantization, Wave-particle duality of material particles, de Broglie equation, Heisenberg Uncertainty principle, Concept of operators (operator–operand), Algebra of operators, commutative and non-commutative operators, linear operator, Laplacian operator, Hamiltonian operator, Eigen value, Eigen function, class Q function, Hermitian operator. Schrodinger wave equation for particles, Eigen values and Eigen functions, postulates of quantum mechanics. Application of Schrodinger equation to a free particle (one dimension and three dimensions). Degeneracy, Wave equation for H-atom, Physical interpretation of wave function, separation and solution of R, ϕ and θ equations. Orbital and spin momentum interpretation. Particle in a box, Application of Schrodinger equation to rigid rotator and harmonic oscillator. Approximate methods – approximate methods, perturbation method, the theory of perturbation method – first order and second order corrections, application to He-atom (first order correction only) – calculation of first ionization potential and binding energy. Variation theorem: statement

and proof. Orbitals shapes and electron density distribution, quantum mechanics in periodic properties, MO formation, Quantum tunneling.

Unit II

Symmetry elements and symmetry operations, point groups, examples. Group theory: Concept of a group, definition of a point group, procedure for classification of molecules into point groups. Subgroups. Schoenflies and Hermann-Maugin symbols for point groups. Multiplication tables for the symmetry operations of simple molecules. Matrix notation for the symmetry elements and for geometric transformations. Class of a group and similarity transformation.

Representation of groups: Reducible and irreducible representations. Labeling of irreducible representations. Group theory and hybrid orbitals to form bonds. Character tables (Cs, Ci, C_2, C_{2V}, C_2h), GOT.

Applications of group theory: Symmetries of Molecular orbitals, Basic MOT, orbital symmetries, Applications of group theory to crystal field, Symmetry and dipole moments, symmetry and optical activity, crystallography.

UNIT – III

Microwave spectroscopy: Rotation spectra of diatomic Molecules - rigid and non-rigid rotator model. Rotational quantum number and selection rule. Effect of isotopic substitution on rotation spectra. Classification of polyatomic molecules based on moment of inertia - Linear, symmetric top, asymmetric top and spherical molecules.

Rotation spectra of polyatomic molecules, Moment of inertia expression for linear tri-atomic molecules. Applications - Principles of determination of Bond length and moment of inertia from rotational spectra. determination of dipole moments.

Vibration spectroscopy*:* Vibration of diatomic molecules, vibrational energy curves for simple harmonic oscillator. Effects of anharmonic oscillation. Vibration - rotation spectra of carbon monoxide. Expressions for fundamental and overtone frequencies. Vibration of polyatomic molecules – The number of degrees of freedom of vibration and their symmetry. Parallel and perpendicular vibrations (CO_2 and H_2O). Fundamental, overtone, combination and difference bands. Fermi resonance. Force constant and its significance. Theory of infrared absorption and theoretical group frequency. Intensity of absorption band and types of absorptions. Structures of small molecules: XY_2. Factors affecting the group frequency – Physical state, vibrational coupling, electrical effect, hydrogen bonding, steric effect and ring strain.

UNIT – IV

Raman spectroscopy: Introduction, Raman and Rayleigh scattering, Stokes and anti-Stokes lines, polarization of Raman lines, depolarization factor, polarizability ellipsoid. Theories of Raman spectra -

classical and quantum theory. Rotation-Raman and vibration-Raman spectra. Comparison of Raman and IR spectra, rule of mutual exclusion principle.

Electronic Spectroscopy: Franck-Condon principle, Transition moments, assignment of electronic transitions of N_2, H_2O and formaldehyde using group theory, solvent effect,

Introduction to NMR:- Origin of magnetic moments in matter, electronic and nuclear moments, interaction with magnetic field, Larmor equation - conditions for magnetic resonance absorption, relaxation times, line widths and line shapes, chemical shifts, ring currents, diamagnetic anisotropy, solvent effect, Hydrogen bonding effect, spin-spin splitting, Coupling constant, high resolution NMR spectra of simple molecules, first and second order treatment of AB systems - FT techniques. C^{13}NMR introduction, problems and structure solution.

Other Resonance Spectroscopy Methods:- EPR, Electron spin resonance: g value, hyperfine and fine structure, ESR of organic free radicals, ESR of solids, ESR of inorganic ions, ESR of simple free radicals in solutions.

References:

1. Lewis and Glasstone, Elements of Physical Chemistry, The Sciencec Study series, Macmillian, 1963
2. P.W. Atkins, Physical Chemistry, ELBS, Oxford University Press 4th Edition, (1990).
3. W.J. Moore, Basic Physical Chemistry, Prentice Hall, New Delhi, (1986).
4. G.M. Barrow, Physical Chemistry, McGraw Hill International Service (1988).
5. A.K. Chandra, Quantum Chemistry, Tata McGraw Hill Publishing Co. Ltd., 2nd Edition, (1983).
6. Eyring, Walter and Kimball, Quantum Chemistry, John Wiley and Sons, Inc., New York.
7. Quantum Chemistry, I.N. Levine. Pearson Education, New Delhi, (2000).
8. Theoretical Chemistry, S. Glasstone. East West Press, New Delhi, (1973).
9. Quantum Chemistry, R.K. Prasad, New Age International Publishers, (1996).83)
10. D.A. McQuarrie. Quantum Chemistry, University Science book publishers, 1983
11. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, New Delhi. 4th Edition,
12. Pavia, Lampman and Kriz, Introduction to Spectroscopy, Thomson. Learning academy resources, 3rd Edition, 2001
13. B.P. Straughan and S. Walker, Spectroscopy, John Wiley & Sons Inc., New York, Vol. 1 and 2, (1976).
14. D.N. Satyanarayana, Vibration Spectroscopy Theory and Applications, New Age International, New Delhi.
15. Alberty, Silbey, Bawendi, Physical Chemsitry, Wiley, 4th Edition, 2004

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0203	CO1	2	3	2	2	2	1			1	2	2	2	2
	CO2	2	2	1	2	2	1			1	2	2	1	2
	CO3	2	3	2	2	2	1			1	2	2	2	3
	CO4	3	3	2	2	2	1			1	2	3	2	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0204	ORGANIC SPECTROSCOPY	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Device the basic concepts of UV-Visible and IR spectroscopic techniques to analyze the chemical compound and structure,

ii. Analyze the organic compound structure by using the knowledge of Chemical shift values and data interpretation.

iii. Evaluate the mass of the organic compound by the fragmentation pattern and study the compounds by different modern ionization techniques.

iv. Illustrate the of unpaired electron compounds by the principle of ESR technique and Elucidate the structure of organic compound by using the spectral data.

Course Outcomes:

By the completion of course student will be able to

CO1. Conclude the structure and composition by using the UV-Visible and IR spectroscopic techniques.

CO2. Apply the knowledge of nuclear spin resonance phenomenon to identify the structure of compounds by the chemical shift values of shielded and De-shielded compounds.

CO3. Evaluate the mass of the compound by the knowledge of ionization, fragmentation in the process of structure analysis.

CO4. Decide the structure of unpaired electron system and elucidate the structure of organic compound by using the spectral data.

Course Content:

UNIT-I

UV AND Visible Spectroscopy: Introduction to EMR, principle and instrumentation, Terminology, classification of electronic transitions. Effect of substituent and conjugation on the spectra of alkenes. Electronic spectra of carbonyl compounds. Effect of solvent on $\pi - \pi^*$ and $n - \pi^*$ transitions. Woodward's rules for calculating absorption maximum in dienes, carbonyl compounds, Applications and structure analysis.

Infrared Spectroscopy: Principle and instrumentation, types of IR vibrational bands, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters,

amides.). Effect of solvent, Electronic effects and hydrogen bonding on the vibrational frequencies in alcohols. Applications and structure analysis. **[15 hrs]**

UNIT-II

H^1-NMR Spectroscopy: Introduction, basic principles and instrumentation of NMR spectroscopy. The chemical shift and shielding. Factors affecting chemical shift. Magnetic anisotropy, electronic effects, hydrogen bonding. Relaxation processes. Spin – spin coupling and splitting of NMR signals. Spin – spin interactions – AX, AX2, AX3, AMX and AB types. The coupling constant. Intensities of multiplets – Pascal's triangle. Equivalence of protons – chemical and magnetic equivalence. Low and high-resolution spectra of ethanol – chemical exchange. Geminal and vicinal coupling. Karplus equation and Karplus curve. Effect of hindered rotation on the NMR spectrum.

C^{13}-NMR Spectroscopy: The carbon – 13 nucleus, carbon – 13 chemical shift. Proton coupled and proton decoupled carbon – 13 spectra. NOE, COSY, HETCOR, Problems with integration in carbon -13 spectra. Off resonance decoupling. Applications in structural elucidation. **[15 hrs]**

UNIT-III

Mass Spectrometry: Introduction, principle and instrumentation. Ion production electron impact, chemical ionization, field desorption and fast atom bombardment, APCI, MALDI techniques. High resolution mass spectrometry base peak, molecular ion, parent ion, fragmentation ion, metastable and isotopic peaks. Factors affecting fragmentation, ion analysis and ion abundance. Mass spectral fragmentation of organic compounds (hydrocarbons, aromatic compounds, alcohols, carbonyl compounds). Mc-Lafferty rearrangement, ortho-effect. Determination of molecular weight and molecular formula. Structuralelucidation. **[15 hrs]**

UNIT-IV

Electron Spin Resonance Spectroscopy: Theoretical principle and Instrumentation, 'g' factor, hyperfine splitting, Kramers degeneracy. Illustration of hyperfine splitting using examples, cyclopentadienyl radical, radical anions of benzene, naphthalene, p-benzosemi Quinone. Isotropic spectra of some transition metal complexes and compounds, bis(salicylaldimine) Cu(II), $[VO(glycolate)_2]^{-2}$, $[(NH_3)_5Co\text{-}O\text{-}O\text{-}Co(NH_3)_5]^{5+}$, Mn^{2+} as a substitution impurity in MgO.

Structuralelucidation of different organic compounds by using the spectral data. **[15 hrs]**

References:

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein and W.P. Webster, Wiley & Sons, (1999).

2. Principles of Instrumental Analysis, 5th Edition,D.A. Skoog, S.J. Holler, T.A. Nilman, Saunders College Publishing, London, (1998).

3. Organic spectroscopy, 3rd Edition, Willium Kemp, Palgrave, London (1991).

4. Organic spectroscopy, L.D.S Yadav, Sprnger, Dordrecht (2005).

5. Molecular spectroscopy, C.N. Banwell, third edition, MC graw-Hill, London (1983).

6. Organic spectroscopy, Y.R. Sharma

7. Introduction to Spectroscopy, Donald Pavia.

Mapping of Course Outcomes with programme Outcomes

c	**POS/ Cos**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21S M0204	CO1	1	2	1	2	3	1	3	2	2	2	2	3	3
	CO2	1	2	2	2	3	2	3	1	2	2	2	2	3
	CO3	1	2	1	1	3	2	3	1	2	2	2	2	3
	CO4	1	1	1	1	2	1	2	1	2	1	2	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0205	CHALLENGES IN INDUSTRIAL RESEARCH AND DEVELOPMENT	AECC/HC	2	0	0	2	2

COURSE OBJECTIVES:

This course enables the students to

1. Understand the industrial protocols and regulations
2. Gain sufficient information about the resources and uses of chemicals
3. Demonstrate the concepts of manufacturing
4. Develop the knowledge on GLP and GMP

COURSE OUTCOMES:

After the completion of the course, a student should be able to

1. Appreciate the importance of standard operating procedures
2. Understand the significant aspects of process development
3. Assess the impact of chemicals on environment
4. Realize the various safety regulations in industries

Unit 1

Introduction and importance of chemistry research, Basic research methodologies, literature survey, research Journals, research ethics and practices, bridging gaps: Academics to industry translation, product requirements and developments, challenges, patents, Industrial requirements. Vital industrial R&D

Unit 2

Green Chemistry, Principles, Pollution prevention, Atom economy, Less hazardous chemical syntheses , Designing safer chemicals, Safer solvents and auxiliaries, Design for energy efficiency, Use of renewable feed stocks, Reduce derivatives, Catalysis, Design for degradation, Real-time analysis for pollution prevention, Inherently safer chemistry for accident prevention.

Unit 3

Characteristics of the industry, Scale of operations, Chemical production, Major sectors and their products, Turning chemicals into useful end products, Environmental issues, Sources of organic chemicals, Organic chemicals from oil and natural gas, Organic chemicals from coal, Organic chemicals from carbohydrates, Organic chemicals from animal and vegetable oils and fats, Sources of inorganic chemicals, Recycling of materials, Catalysis, Essential features, Initiators, Co-reactants, Inhibition, Homogeneous and Heterogeneous catalysis, Applications and Mechanisms, Petrochemicals, Crude oil, gas and refinery operations, Lower olefins and acetylene, Synthesis gas, ammonia and methanol, Acetic acid and anhydride, C1, C2, C3 and C4 products, C5 aliphatics, Aromatics, Nylons.

Unit 4

Research and Development, Manufacturing, Intent of Regulations, Regulatory authorities, U.S. Food and Drug Administration (FDA), GLP and GMP, Organization and Personnel, Facilities and Equipments, Testing Facilities, Control articles, Nonclinical studies, Laboratory Controls, Control of Components and Drug Products, Production and Process Controls, Packaging and Labeling Control, Holding and Distribution, Records and Reports, Documentation

***

The subject requires

Minor Project with respective research mentors, Industrial Visit, Thesis/Report - weightage 20 %

Bibliography

1. An Introduction to Industrial Chemistry, Second Edition, C. R, Heaton, Blackie Academic & Professional, 1992

2. Handbook of Industrial Chemistry, Organic Chemicals, M. Ali, Bassam El Ali, McGraw Hill, 2005

3. Fundamentals of Industrial Chemistry, John A. Tyrell, Wiley, 2014

4. Organic Chemistry Principles and Industrial Practice, Mark M. Green, Harold A. Wittcoff, De Gruyter, 2003

5. Industrial Inorganic Chemistry, Mark Anthony Benvenuto, De Gruyter, 2015.

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8		PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0205	**CO1**	**2**	**1**	**2**	**1**	**2**	**1**	**1**				**1**	**3**	**1**	**2**
	CO2	**3**	**2**	**1**	**2**	**2**	**3**	**2**				**1**	**1**	**1**	**3**
	CO3	**2**	**2**	**2**	**3**	**3**	**2**	**1**				**1**	**3**	**1**	**2**
	CO4	**3**	**2**	**1**	**2**	**1**	**2**	**2**				**1**	**3**	**1**	**2**

SEMESTER-II: SOFTCORE (SC)

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS201	CHEMISTRY OF LIFE	SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Knowledge on green chemistry concepts.
ii. Applications of various green technology in materials synthesis.
iii. Class of green chemicals and compounds for sustainability.
iv. Categorization of reaction mechanisms and schemes for green synthesis.

Course Outcomes:

By the completion of course student will be able to

CO1. Discriminate the role metal ions in biological systems.
CO2. Categorize biomolecules based on their biological functioning.
CO3. Appraise the role of chemistry principles in biological systems.
CO4. Explain the role of analytical techniques in the purification of biomolecules.

Course Content:

UNIT-I

Bioinorganic chemistry: Introduction to elements and their occurrence, role of some alkali, alkaline and transition elements in Biosystems. Basic principle of selection of metal ions in Biosystems; Irving – Williams's series and its significance. HSAB concept-classification and its importance. Relationship between ionic specificity and field strength. Coordination sites in biomolecules (Proteins, DNA and Vitamins). Respiratory Proteins; Iron storage proteins (Ferritin, apoferritin and Transferrin). Structural aspects of Haemoglobin and myoglobin and their role in oxygen transport. Spin state of iron, Spatial and electronic aspects in dioxygen binding (about d-configuration), oxygenation curve (Bohr Effect). Functional aspects of Cytochromes (c, c oxidase and P-450), Copper-Blue proteins (Type – I, II and III), Fe-S proteins (Rubredoxin and Ferredoxins), peroxidase, catalase, Molybdenum and tungsten enzymes in Biosystems. Bio mineralization (role of Minerals). **[12 hrs]**

UNIT-II

Physical Chemistry in Bio-systems: Bio electrochemistry: Electrochemical cells and membrane potentials, nature of driving forces, origin of membrane potentials, electrochemical potential and Nernst

equation for Electroneutrality. Introduction to bilayer lipid membranes and its structure. Membrane transport; purpose of transport process, factors governing permeation and transport, the nature of driving force (Fick's law of diffusion). Types of transport; active, facilitated and passive transports (terms involved), example of K^+/Na^+ pump and Na^+/Ca^{2+} pumps across the membranes (for all the cases diagrammatic representations). Properties of lipids described using chemical potential and phenomenon of lipid and detergent formation into micelles and bilayers. Determination of micelle formation using surface tension. Enzyme catalysis, and its kinetics- Michaelis-Menten equation, and its modified form and Lineweaver–Burk plot; enzyme inhibition types (competitive, non-competitive and un-competitive) and Lineweaver–Burk plots. Osmosis and Donnan membrane potential and its biological significance. Protein solubility and crystallisation; principle (Hoffmeister series) "Salting In" and "Salting Out" for protein purification.

[12 hrs]

UNIT-III

Bioenergetics: Oxidation and reduction reactions and bioenergetics (concept of midpoint potential). The central role of ATP in Metabolism and its stability. Mitochondrial flow of electrons from NADH to O_2. Oxidative phosphorylation and respiratory chain. Energetics of electron transfer –I (Introduction to Marcus theory and Frank Condon principle). Thermodynamic principles in coupled reactions (endothermic & exothermic). Mechanism of muscle contraction – role of actin and myosin in presence of ATP. Introduction to enthalpy, free energy, entropy, heat capacity and chemical potential.

Application of some instrumental techniques in the study of biomolecules:

(i) Differential Scanning Calorimetry and ITC: Principle, instrumentation and its application in the study of folding and unfolding biomolecules such as, DNA and proteins.

(ii) Circular Dichroism: Principle, instrumentation and general explanation for its application in the study of based on chirality in proteins and chirality of bases due to double helix model of the DNA. **[12 hrs]**

UNIT-IV

Bio-organic chemistry: Interactions in Bio systems; hydrogen bonding (in proteins, Nucleic acid, Carbohydrates), Vander walls forces, electrostatic, hydrophobic (Apolar bond), stacking and covalent interactions. Proteins structures (primary, secondary, tertiary and quaternary). Protein folding and unfolding. Detection of intrastrand disulfide bonds in proteins hierarchy of structural organization. Introduction to biopolymers; DNA and its polymerisation, RNA, Chemical methods involved in sequencing of DNA and Proteins. Chemical and biochemical synthesis of DNA- Phosphoramidite method and replication. Chemical and biochemical synthesis of peptides/proteins- solution phase and solid phase peptide synthesis methods and ribosomal synthesis of proteins. Applications of PNAS.

Non-redox metalloenzymes and their functions: Carboxypeptidase-A, alcohol dehydrogenase, leucine aminopeptidase and carbonic anhydrase (Nitrogen cycle). **[12 hrs]**

Self-study: Protein folding and Prions

References:

1. Bioinorganic Chemistry, 2nd Edition, W. Kaim, John Wiley (2013).
2. Inorganic Chemistry, D. F. Shriver, P. W. Atkins, C. H. Langford, ELBS (1990).
3. Biophysical Chemistry, C.R. Cantor & P.R. Schimmel, W.H. Freeman & Company, (1980).
4. Introduction to Bioorganic Chemistry and Chemical Biology, David Van Vranken and Gregory A, Garland Science (Taylor & Francis), (2012).
5. Advanced Organic Chemistry, I.L. Finar, Vol. 2 ELBS, New Delhi, (1975).
6. Biophysical Chemistry- Principle and Technique,A. Upadhyay, K. Upadhyay and N. Nath, Himalaya Publishing House, Bombay, (1998).
7. Bioinorganic Chemistry, K. Hussain Reddy, New Age International Publishers, (2003).
8. Biophysical Chemistry, Alan Cooper, Glasgow University, RSC, (2004).
9. Biophysical Chemistry, James P. Allen, Wiley – Blackwell Publication, (2008).
10. Bioinorganic Chemistry,Ivano Bertini, Harry B. Gray, Stephen J. Lippard and Joan Swlverstone Valentine, University Science Books, (1994).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS201	CO1	1	1			2	2					2	2	
	CO2	2	1		1	2	1					1	2	2
	CO3	2	2		1	2	2					2		2
	CO4	2	2		2	2	2					2	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS202	INTRODUCTION TO MEDICINAL CHEMISTRY	DSEC*/SC	2	0	0	2	2

Course Objectives:

i. This course will deal with the topics which provide insights on how the different substrates act as drug targets.

ii. Various aspects of the drug discovery such as pharmacokinetics, structure-activity relationships and computer assisted drug discovery will be examined.

iii. The mechanism of action of antibacterial agents and bacterial resistance to antibiotics will be explored.

iv. The cause of the cancer and the mode of action of anticancer agents will be surveyed.

Course Outcomes:

On successful completion of this course the student shall be able to:

CO1. Understand the importance of drug targets and its relevance for drug discovery.

CO2. Analyze the concepts of pharmacokinetics and structure-activity relationships.

CO3. Identify the mechanism of action of antibacterial agents, and the causes of bacterial resistance.

CO4. Evaluate anticancer agents based on therapeutic applications and mode of action.

Course Content:

UNIT - I

Drug Targets

Enzymes: Inhibitors acting at the active site of an enzyme, Inhibitors acting at allosteric binding sites, Uncompetitive and non-competitive inhibitors, Transition-state analogues, Suicide substrates, Isozyme selectivity of inhibitors, Enzyme inhibitors, Enzyme kinetics

Receptors: Agonists, Antagonists, Partial agonists, Inverse agonists, Desensitization and sensitization, Tolerance and dependence, Receptor types and subtypes, Affinity, efficacy, and potency

Nucleic acids: Intercalating drugs acting on DNA, Topoisomerase poisons, Alkylating and metallating agents, Chain cutters, Chain terminators, Control of gene transcription, Agents that act on RNA

Miscellaneous: Transport proteins as drug targets, Structural proteins as drug targets, Biosynthetic building blocks as drug targets, Biosynthetic processes as drug targets, Protein-protein interactions, Lipids as drug targets, Carbohydrates as drug targets. **[12hrs]**

UNIT - II

Pharmacokinetics

Drug absorption, Drug distribution, Drug metabolism, Drug excretion, Drug administration, Drug dosing, Formulation, Drug delivery

Quantitative Structure - Activity Relationships (QSAR)

Hydrophobicity, Electronic effects, steric factors, Hansch equation, The Craig plot, The Topliss scheme, Bioisosteres, Three-dimensional QSAR (CoMFA)

Computers in Medicinal Chemistry

Molecular mechanics, Quantum mechanics, Energy minimization, Conformational analysis, Structure comparisons and overlays, Identifying the active conformation, 3D Pharmacophore identification, Docking procedures, Automated screening, Protein mapping, *De novo* drug design. **[12 hrs]**

UNIT – III

Antibacterial Agents

Bacterial cell, Mechanisms of antibacterial action

Antibacterial agents which act against cell metabolism - Sulphonamides

Antibacterial agents which inhibit cell wall synthesis - Penicillins, Cephalosporins, Other β-lactam antibiotics, β-Lactamase inhibitors, other drugs which act on bacterial cell wall biosynthesis

Antibacterial agents which act on the plasma membrane structure - Valinomycin and gramicidin A, Polymyxin B, Killer nanotubes, Cyclic lipopeptides

Antibacterial agents which impair protein synthesis: translation - Aminoglycosides, Tetracyclines, Chloramphenicol, Macrolides, Lincosamides, Streptogramins, Oxazolidinones

Agents that act on nucleic acid transcription and replication - Quinolones and fluoroquinolones, Aminoacridines, Rifamycins, Nitroimidazoles and nitrofurantoin, Inhibitors of bacterial RNA polymerase

Miscellaneous agents, Drug resistance - Drug resistance by mutation, Drug resistance by genetic transfer. **[12hrs]**

UNIT - IV

Anticancer agents

Cancer - Causes of cancer, Genetic faults leading to cancer: proto-oncogenes and oncogenes, Abnormal signalling pathways, Insensitivity to growth-inhibitory signals, Abnormalities in cell cycle regulation, Apoptosis and the p53 protein, Telomeres, Angiogenesis, Tissue invasion and metastasis, Treatment of cancer, Resistance

Drugs acting directly on nucleic acids - Intercalating agents, Non-intercalating agents, Alkylating and metallating agents, Chain cutters, Antisense therapy

Drugs acting on enzymes: antimetabolites - Dihydrofolate reductase inhibitors, Inhibitors of thymidylate synthase, Inhibitors of ribonucleotide reductase, Inhibitors of adenosine deaminase, Inhibitors of DNA polymerases, Purine antagonists, Inhibitors of poly ADP ribose polymerase

Hormone-based therapies - Glucocorticoids, estrogens, progestins, and androgens, Luteinizing hormone-releasing hormone agonists, Anti-estrogens, Anti-androgens, Aromatase inhibitors

Drugs acting on structural proteins - Agents which inhibit tubulin polymerization, Agents which inhibit tubulin depolymerisation

Inhibitors of signalling pathways - Inhibition of farnesyl transferase and the Ras protein, Protein kinase inhibitors

Miscellaneous enzyme inhibitors - Matrix metalloproteinase inhibitors, Proteasome inhibitors, Histone deacetylase inhibitors, other enzyme targets

Miscellaneous anticancer agents - Synthetic agents, Natural products, Protein therapy, Modulation of transcription factor – co-activator interactions

Antibodies, antibody conjugates and gene therapy - Monoclonal antibodies, Antibody-drug conjugates, Antibody-directed enzyme prodrug therapy (ADEPT), Antibody-directed abzyme prodrug therapy (ADAPT), Gene-directed enzyme prodrug therapy (GDEPT), other forms of gene therapy

Photodynamic therapy. **[12hrs]**

References:

1. Text Book of Organic Medicinal and Pharmaceutical Chemistry, 12thEdition,John M. Beale Jr., John H. Block, Wolters Kluwer/Lippincott Williams & Wilkins, Baltimore, (2011).
2. Medicinal Chemistry an Introduction, 2nd Edition, Gareth Thomas, Wiley, England, (2007).
3. An Introduction to Medicinal Chemistry, 5th Edition, Graham L. Patrick, Oxford University Press, Oxford, (2013).
4. Medicinal Chemistry: A Molecular and Biochemical Approach, 3rdEdition, Thomas Nogrady, Donald F. Weaver, Oxford University Press, Oxford, (2005).
5. Pharmaceutical Chemistry, 1stEdition, David G. Watson, Churchill Livingstone/Elsevier, Edinburgh, (2011).
6. The Organic Chemistry of Drug Design and Drug Action, 3rdEdition, Richard B. Silverman, Mark W. Holladay, Elsevier, San Diego, (2014).
7. Foye's Principles of Medicinal Chemistry, 7thEdition, Thomas L. Lemke, David A. Williams, Victoria F. Roche, S. William Zito, Lippincott Williams and Wilkins/Wolters Kluwer, Baltimore, (2013).
8. Pharmacology, 5thEdition,Michelle A. Clark, Richard Finkel, Jose A. Rey, Karen Whalen, Wolters Kluwer/Lippincott Williams and Wilkins, Baltimore, (2012).
9. Molecular Biology, 3rdEdition, Phil Turner, Alexander McLennan, Andy Bates, Mike White, Taylor &Francis, New York, (2005).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS202	CO1	2	1	2	1	2	1	1			1	2	1	2
	CO2	3	1	1	2	2	1	2			1	2	1	3
	CO3	2	2	2	1	3	2	2			1	2	1	2
	CO4	3	2	1	2	1	2	2			1	3	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS203	ADVANCED CHEMICAL KINETICS AND THERMODYNAMICS	SC	2	0	0	2	2

Course Objectives:

i. To provide the student with principles and kinetic tools useful in analyzing the rates of chemical reactions for both homogeneous and heterogenous reactions.

ii. To increase the student's ability to do chemical reactor design by providing the knowledge and tools required to obtain, evaluate, and improve rate equations for use in design, operation and optimization of chemical reactors.

iii. To present a comprehensive and rigorous treatment of classical thermodynamics while retaining an engineering perspective.

iv. To lay the groundwork for subsequent studies in such fields as fluid mechanics, heat transfer and to prepare the students to effectively use thermodynamics in the practice of industry.

v. To develop an intuitive understanding of thermodynamics by emphasizing the physics and physical arguments.

vi. To present a wealth of real world industrial examples to give students a feel for how thermodynamics is applied in engineering practice.

Course Outcomes:

By the completion of course student will,

CO1. Acquire knowledge on theories of reaction rates, Kinetics of Unimolecular and bimolecular photo physical and photochemical processes.

CO2. Classify the activation and diffusion-controlled processes, different types of overpotentials, Kinetics in the Excited State.

CO3. Explain the concept of thermodynamic work. Calculate and compare work in case of a closed system executing different thermodynamic processes or different thermodynamic cycles.

CO4. Get knowledge about advanced solution thermodynamics, Modern experimental techniques.

Course Content:

UNIT – I

Chemical kinetics: Overview of theories of Reaction Rates, Potential energy surfaces-adiabatic and non-adiabatic curve crossing Processes- transition state theory- activation/thermodynamic parameters. Various theories of Unimolecular reactions (Lindemann- Christiansen hypothesis; Hinshelwood, RRK and RRKM theories; non RRKM behavior)

Elementary Reactions in Solutions: Influence of solvent properties on rate. Different types of molecular interactions in solution. Diffusion and activation-controlled reactions.

Kinetics in the Excited State: Jablonski diagram. Kinetics of Unimolecular and bimolecular photophysical and photochemical processes. Resonance energy transfer rates-Fluorescence quenching kinetics in solution and gas phase. **[8 hrs]**

UNIT – II

Electrode Kinetics: Metal/solution interface: Dependence of electrochemical reaction rate on overpotential-current density for single step and multi-step processes-Influence of electrical double layer on rate constants. Activation and diffusion-controlled processes- Marcus kinetics and quadratic dependence of Gibbs free energies-electron transfer processes involving organic and inorganic compounds. Different types of overpotentials- polarization behavior-Mechanism of hydrogen evolution and oxygen reduction in acid and alkaline media- Experimental methods for elucidation of reaction mechanism.

[8 hrs]

UNIT – III

Applications of Chemical Kinetics: Homogenous catalysis: Acid-base catalysis, specific acid and base catalysis. General acid and base catalysis. Oxidation of amino acids and carbohydrates in presence of acid and base catalysis. Acidity functions - Bronstead, Hückel, Hammett and Bunnett hypothesis.

Chain reactions: Rice-Herzfeld mechanism for the thermal decomposition of acetaldehyde, Kinetics of explosive reactions, explosion limits (H_2 and O_2 reaction). Kinetics of autocatalytic and oscillatory chemical reactions, oscillatory chemical reaction of oxidation of malic acid by bromate ion catalyzed by Ce(III). Catalyzed and uncatalyzed reaction: Ru(III) catalyzed oxidation reaction of primary amines by chloramine – T in HCl medium.

Heterogenous catalysis, surface and interaction with solids, kinetics of reactions of solids. **[7 hrs]**

UNIT – IV

Advanced solution thermodynamics: Ideal and non-ideal solutions, activity and activity coefficients, mixing and excess properties of liquid-liquid mixtures. Theories of solutions of electrolyte and non-electrolyte liquids: van Laar theory, van der Waals theory, Scatchard-Hildebrand theory, Lattice theory.

Modern experimental techniques: determination of vapour-liquid equilibrium by static and dynamic methods, heat capacity and heat of mixing by calorimeters, and determination of volumetric, transport, acoustic and optical properties of liquid-liquid mixtures. Partial molar properties, their physical significance and methods of their determination. Study of non-ideal behaviour of various types of solutions: nonpolar + nonpolar, polar + nonpolar, polar + polar, and mixtures with hydrogen-bond formation and charge transfer complexes; interpretation in terms of molecular interactions. **[7 hrs]**

References:

1. Text Book of Physical Chemistry, 2nd Edition, Samuel Glasstone, MacMillan Indian Ltd., (1974).
2. Elements of Physical Chemistry, S. Glasstone, MacMillan.
3. Solid State Chemistry, N.B. Hannay.
4. A Text Book of Physical Chemistry, G.M. Barrow, Mc Graw Hill – Tokyo, (1973).
5. Elements of Physical Chemistry, Lewis and Glasstone.
6. Theoretical Chemistry, S. Glasstone.
7. Statistical Themodynamics, B.C. Meclelland, Chapman and Hall, London (1973).
8. Elementary Statistical Thermodynamics, N.D. Smith Plenum Press, NY (1982).
9. Elements of Classical and Statistical Thermodynamics, L.K. Nash, Addison-Wesley (1970).
10. Statistical Thermodynamics, I.M. Klotz.
11. Introduction to Statistical Thermodynamics, M. Dole, Prantice-Hall, (1962).
12. Chemical Kinetics and Dynamics, 2nd Edition, Jeffrey I Steinfeld, Joseph S. Francisco and William L. Hase, Prentice Hall, (1998).
13. Chemical Kinetics, 3rd Edition 1997, K. J. Laidler, Benjamin-Cummings. Indian reprint – Pearson,(2009).
14. Laser Spectroscopy, 3rd Edition, Basic concepts and instrumentation, W. Demtroder, Springer,(2004).
15. Fundamentals of Photochemistry, K. K. Rohatgi, Mukkerjee, Wiley Eastern Ltd., (1992).
16. Electrode kinetics, W. J. Albery, Clarendon Press, Oxford (1975).
17. Comprehensive chemical kinetics, C.H. Banford and R.G. Compton (ed),Vol 26, Electrode kinetics – principles and methodology, Elsevier science publishers (1986).

Mapping of Course Outcomes with Pogramme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS03	CO1	2	1	2	1	2	1	1	1	2	1	2	1	2
	CO2	3	1	1	2	2	1	2	1	1	1	2	1	3
	CO3	2	2	2	1	3	2	2	1	1	1	2	1	2
	CO4	3	2	1	2	1	2	2	1	1	1	3	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS204	SEPARATION AND ELECTRO ANALYTICAL TECHNIQUES-II.4	DSEC*/SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Detailed theoretical background of various separation and electroanalytical techniques.
ii. Various types of liquid chromatographic techniques.
iii. Detailed working of both GC and HPLC techniques.
iv. Principle and applications, also electro analytical techniques like electrophoresis and Voltammetry.

Course outcomes:

By the completion of course student will be able to

CO1. Apprise the use of various separation techniques for sample analysis.
CO2. Categorize specificity of analytical techniques based on nature of the sample.
CO3. Analyse principles that govern compounds separation.
CO4. Outline the role of electroanalytical techniques for materials analysis.

Course Content:

UNIT - I: Liquid chromatographic techniques

(i) Reversed phase chromatography: Objectives, mechanism of reversed phase HPLC, applications of reversed phase HPLC, analyte, retention in reversed phase HPLC, retention order in reversed phase HPLC, reversed phase mobile phase solvents, solvent properties, mobile phase strength and retention, role of organic modifier, eluotropic Series, selecting reversed phase columns, buffers for reversed phase HPLC.

(ii) Normal phase Chromatography: Objectives, mechanism of normal phase chromatography, retention and Selectivity in normal Phase chromatography, separation of isomers using normal phase chromatography, mechanism of isomer recognition in normal phase HPLC, stationary phases for normal phase HPLC, typical mobile phases HPLC, controlling retention, mobile phase optimisation, problems with Water in the mobile Phase

(iii) Ion Exchange chromatography- ion exchangers, ion exchange resins, ion exchange selectivity and selectivity coefficient, Donnan equilibrium, conducting ion exchange chromatography, applications

(vi) Affinity chromatography – working principle, components - Matrix, ligand, spacer arm and their required for efficient and effective chromatographic, matrix-partial structure of agarose-Types of ligands-need of spacer arm. Immobilized metal affinity chromatography.

(v) Introduction to UPLC: Basic principle, difference between HPLC and UPLC, Instrumentation – sample injection, columns, detectors, applications, advantages and dis advantages. **[8 hrs]**

UNIT-II

Gas Chromatography: Separation process in gas chromatography with schematic diagram, open and closed tubular columns and comparison, effect of column inner diameter and length of the Column, choice of liquid stationary phase, chiral phases for separating optical isomers, molecular sieves as stationary phase, retention index, temperature and pressure programming, role of Van -Deemter principle in carrier gas selection, types of columns in HPLC - Guard columns and retention gaps, mode of sample injections - split injection, split less injection, and on column injection, detector characteristics-signal to noise ratio, detection limits, Linearity.

Detectors-thermal conductivity detector, flame ionisation detector, electron capture detector, naming of other detectors,GC- MS-Element specific plasma detectors, Sample preparation-solid phase micro extraction, purge and trap, derivatisation in GC, method development in GC. **[7 hrs]**

UNIT-III

High-Performance Liquid Chromatography: The chromatographic process-effect of small particles, scaling relation between columns, relation between number of theoretical plates and particle size, column pressure, stationary phase and bonded stationary phases, monolithic silica columns, The elution process - isocratic and gradient elution, selecting the separation mode, maintaining symmetric band shape, dead volume, Injection and detection in HPLC, Detector characteristics, signal to noise ratio, detection limits, Linearity, detectors - Spectro-photometric detectors, refractive index detector, Evaporative Light scattering detector, Method development in reverse phase separation, criteria for adequate separation, solvent optimisation - optimisation with one organic solvent, optimization with two or three different organic solvents, choosing a stationary phase, Gradient separations- Dwell volume and Dwell time, Chiral separation techniques. **[7 hrs]**

UNIT-IV Electrodes and voltammetric techniques

Electrodes: Baisc principles,Reference electrodes, metallic indicator electrodes- electrodes of first and second kind, redox electrodes, membrane electrodes-membrane potential, selectivity of membrane, glass ion selective electrodes- Composition and structure of glass membrane, Hygroscopicity of glass membrane, membrane and boundary potential and expression for Eb, alkaline error, crystalline membrane electrode, conductivity of a crystalline membrane, solid state ion selective electrode, liquid based ion selective electrodes, gas sensing electrodes, potentiometric biosensors- enzyme electrodes.

Voltammetric techniques: Introduction, Objectives, Common Voltammetric Methods, Direct Methods - Linear Sweep Voltammetry, Sampled DC Polarography, Hydrodynamic Voltammetry, Pulse Methods Normal Pulse Voltammetry, Differential Pulse Voltammetry, Square Wave Voltammetry, Cyclic

Voltammetry - Principle of cyclic Voltammetry, cyclic voltammogram of $K_3[Fe(CN)_6]$, criteria of reversibility of electrochemical reactions, quasi- reversible and irreversible processes, Stripping Methods - Anodic Stripping Voltammetry, Cathodic Stripping Voltammetry, Adsorptive Stripping Voltammetry, Alternating Current Methods - Voltammetry-Instrument. **[8 hrs]**

References:

1. Quantitative Chemical Analysis, 7thEdition, Daniel C.Harris;. W. H. Freeman and Company, New York, (2006).
2. Principles of Instrumental Methods of Analysis, 5thEdition, Skoog, Holler and Nieman, Saunders College Publishing, International Ltd. (1999).
3. Hand Book of Instrumental Techniques For Analytical Chemistry, Frank Settle, Prentice Hall PTR, (1997).
4. Chromatographic methods, 5thEdition, A. Braithwaite and F J Smith, Kulwer Academic publishers.
5. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).
6. Vogel's Text book of quantitative chemical analysis, 6thEdition, Pearson Education Limited, (2007).
7. Electrochemical Methods Fundamentals and Applications, Allen J. Bard and Larry R Faulkner, John Wiley and Sons, (1980).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS204	CO1	2	2		2	1	1					1	2	2
	CO2	2	1		2	1	1					2	2	2
	CO3	2	2	1	1	2	2		1			1	2	1
	CO4	2	1	2	2	2	1		2			2	2	2

SEMESTER-II: PRACTICAL

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SM0206	INORGANIC CHEMISTRY-II PRACTICALS	HC	0	1	2	3	5

Course Objectives:

This course aims to provide the student to

i. Correlate To expose the students to a breadth of experimental techniques using modern instrumentation.

ii. To provide a broad foundation in Chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. Endeavors to contribute to industry and address problems of societal importance.

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

iv. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.

Course Outcomes:

By the completion of course student will be able to

CO1. Have sound knowledge about the fundamentals and applications of chemical and scientific theories

CO2. Analyze the data obtained from sophisticated instruments (like FTIR, NMR, GCMS, HPLC, GCMS UV-Vis, Fluorescence, and TGA) for the structure determination and chemical analysis.

CO3. Acquires the ability to synthesize, separate and characterize compounds using laboratory and instrumentation techniques

CO4. Apply appropriate techniques for the qualitative and quantitative analysis of chemicals in laboratories and in industries.

Course Content:

PART – I

1. Determination of iron in haematite using cerium (IV) solution (0.02M) as the titrant, and gravimetric estimation of insoluble residue.
2. Estimation of calcium and magnesium carbonates in dolomite using EDTA titration, and gravimetric analysis of insoluble residue.
3. Determination of manganese dioxide in pyrolusite using permanganate titration.
4. Quantitative analysis of copper-nickel in alloy/mixture:
   i. Copper volumetrically using KIO_3.

ii. Nickel gravimetrically using DMG

5. Determination of lead and tin in a mixture: Analysis of solder using EDTA titration.

6. Quantitative analysis of chloride and iodide in a mixture:

i. Iodide volumetrically using KIO_3

ii. Total halide gravimetrically

7. Spectrophotometric determinations of:

a. Titanium using hydrogen peroxide

b. Chromium using diphenyl carbazide in industrial effluents

c. Iron using thiocyanate/1, 10-phenanthroline method in commercial samples

d. Nickel using dimethylglyoxime in steel solution

PART – II

Semi micro qualitative analysis of mixtures containing two anions and two cations(excluding sodium, potassium and ammonium cations) and one of the following less common cations: W, Mo, Ce, Th, Ti, Zr, V, U and Li.

References:

1. Vogel's Text Book of Quantitative Chemical Analysis, 5thEdition, J. Basset, R.C.Denney, G.H. Jeffery and J. Mendhom.

2. A Text Book of Quantitative Inorganic Analysis, 3rd Edition, A.I. Vogel,.

3. Spectrophotometric Determination of Elements, Z. Marczenko.

4. Vogel's Qualitative Inorganic Analysis, Svelha.

5. Macro and Semimicro Inorganic Qualitative Analysis, A.I. Vogel.

6. Semimicro Qualitative Analysis, F.J. Welcher and R.B. Halin.

7. Quantitative Chemical Analysis, 7th Edition, Daniel C. Harris, (2006).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S M0206	CO1	3	2	2	2	2	2	2	2	2	2	3	1	
	CO2	2	3	1	2	2	2	1	1	2	2	3	2	1
	CO3	3	2	2	2	3	2	1	3	3	2	3	2	3
	CO4	2	2	2	3	3	2	1	2	2	2	3	2	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week

M21SM0207	ANALYTICAL CHEMISTRY-II PRACTICALS	HC	0	1	2	2	4

Course Objectives:

The practical course on Analytical chemistry intends to provide the students to,

i. Acquire the scientific skills in qualitative and preparative techniques.
ii. Appreciate the importance of being systematic in life.
iii. Understand the chemical methods employed for elemental and compound analysis.
iv. Develop honesty, punctuality, analytical reasoning, questioning, critical evaluation and thinking among students.

Course Out comes:

On successful completion of the practical course students shall be able to:

CO1. Develop practical skills related to analytical chemistry in analysis of constituents present in different samples.

CO2. Illustrate the experimental skills on different instrumental analysis of the given compounds.

CO3. Defend the experimental results with validation.

CO4. Acquire the critical thinking, punctuality, team work and honesty during the conduction of the experiments.

Course Content:

1. Determination of Saponification value and Iodine value of an oil sample.
2. Determination of residual Chlorine in water by Iodometry
3. Flame emission spectrometric determination of sodium and potassium in river/lake water.
4. Analysis of a mixture of iron (II) and iron (III) by EDTA titration using pH control.
5. Potentiometric titration of a mixture of chloride and iodide.
6. Estimation of DO and COD of waste water sample.
7. Spectrophotometric determination of iron in natural waters using thiocyanate and 1,10- phenanthroline as reagents.
8. Conductometric titration of sodium acetate with HCl and NH_4Cl with NaOH.
9. Separation of amino acids in a mixture by TLC using Ninhydrin.
10. Determination of composition of Complex by Job's Method and Mole ratio Method of Cu(II)-EDTA complex
11. Analysis of waste water for alkalinity by visual, pH metric and conductometric titrations.
12. Spectrophotometric determination of Paracetamol.

References:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, Third Indian Reprint, Pearson Education Pvt. Ltd., New Delhi,(2003).
2. Analytical Chemistry Principles, 2nd Edition, John H. Kennedy, Saunders College Publishing, California, (1990).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM 0207	CO1	3	2	1	1	1	2	3	2	2	2	2	1	2
	CO2	1	2	1	1	3	2	2	2	2	2	2	1	2
	CO3	2	2		1	2	2	2	1	2	2	2	1	2
	CO4	1	2	1	1	2	2	2	2	2	1	1	1	2

SEMESTER-III: INORGANIC CHEMISTRY HARD CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ301	ADVANCED INORGANIC CHEMISTRY-III	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Understand the brief of transition metal orbitals, electron counting, formal oxidation state,18-e rule, geometries for transition metal complexes (Crystal Field theory, MO description), σ- and π bonding, metal-metal bonding.

ii. Identify survey of types of ligands for TM complexes and their electronic and steric properties. Typical spectroscopic methods and techniques for the characterization of TM complexes.

iii. Discuss the Chemical processes on TM: ligand exchange, oxidative addition, and reductive elimination, migratory insertion, nucleophilic attach on the ligand. Mechanisms and synthetic outcomes.

iv. Explain the concepts of selected representative applications of TM complexes in catalysis, with emphasis on the impact of modern chemistry on urgent global needs such as processes for clean energy: mechanistic and practical aspects.

Course Outcomes:

By the completion of course student will be able to

CO1. Build the knowledge of inorganic photochemistry, metal complexes in drugs, medicinal bioinorganic chemistry and advance nuclear chemistry.

CO2. Evaluating transition metal coordination compounds in terms of their geometry and interpret at a basic level their electronic properties.

CO3. Explain the Tabulate the coordination complexes undergoing a variety of reactions including electron transfer, ligand exchange and associative process.

CO4. Identifying the shapes and structure of coordination complexes with coordination numbers ranging from 4- 12.

Course Content:

UNIT-I

Ligand substitution reactions of complexes: Labile, inert, stable and unstable complexes, classification of mechanisms - associative (A), dissociative (D) and interchange (I_a and I_d).Mechanism of ligand substitution in octahedral complexes- kinetics, factors affecting substitution in octahedral complexes: Leaving group, chelate and metal effects. Acid-Base catalysis: Acid catalyzed aquation and anation reactions, base hydrolysis, conjugate base hydrolysis, stereochemistry of octahedral substitution. Fuoss-

Eigen equation and factors determining A or D mechanisms, lability and inertness of complexes. Mechanism of ligand substitution in square planar complexes- factors affecting substitution, trans-effect and its theories, cis-effect, designing synthetic routs to cis-platin and other complexes of Pt group elements. Metal exchange and ligand exchange reaction, and reaction of the coordinated ligand. **[15 hrs]**

UNIT – II

Redox process and reactions of coordinated ligands: Electron transfer reactions, complementary and non-complementary, outer sphere electro transfer- Marcus equation, their excited state electron transfer, Inner sphere electron transfer-one and two electron transfer and use of electron transfer reactions for the synthesis of complexes. Kinetics, effect of metal and ligands, Bridging group effects. Mixed metal Complexes (Electron transfer), mixed valence complexes. Mechanism of atom transfer processes, halogen, Oxo-and hydride transfer reactions, electron transfer reactions. Applications of redox process in bioinorganic chemistry: Reactions involving N_2, H_2O_2 and molecular oxygen. Reactions of coordinated Ligands: Acid dissociation, hydrolysis of amino acid esters, peptides, proteins, substitution, amine exchange, trans amination, thermodynamic and kinetic template effects, metal assisted macrocyclization. Chemistry of variable oxidation states of Transition metals: Low and High oxidation states, negative oxidation states, stability, effect of concentrations on stability, electronic configuration, EMF, properties. Application of XPS in oxidation state analysis. MOSSBAUER SPECTROSCOPY: Mossbauer effect and Mossbauer nuclei, isomer shift, quadrupole splitting and magnetic hyperfine interactions, Chemical isomer shift, elucidation of electronic structures of Fe(II) and Fe(III) systems.

[15 hrs]

UNIT-III

Photochemistry of co-ordination complexes: Fundamental concepts, Jablonski diagram, classification of photochemical reaction. Electronic transitions in metal complexes - metal centered and charge transfer transitions - various photophysical and photochemical processes of coordination compounds - unimolecular charge-transfer photochemistry of cobalt (III) complexes - mechanism of CTTM photoreduction. Ligand field photochemistry of Cr(III) complexes - Adamson's rule - photoactive excited states - V-C model - photophysics and photochemistry of Ru-polypyridine complexes - emission and redox properties - photochemistry of organometallic compounds - metal-carbonyl compounds - compounds with metal-metal bonding - Reinecke's salt - chemical actinometer. Application in water photolysis, Nitrogen and CO_2reduction. Metal porphins compounds, phthalocyanines complex, photoinduced emission and aggregation emission. **[15 hrs]**

UNIT-IV

Metal complexes as drugs and therapeutic agents: Introduction, antimicrobial agents, antiviral agents, antiarthritis agents and anticancer agents. Antidote complexes.

Medicinal Bioinorganic Chemistry: Bioinorganic Chemistry of quintessentially toxic metals. Lead, Cadmium, Mercury, Aluminium, Chromium, Iron, Copper, Plutonium. Toxic effects-Mechanism of toxic effects Detoxification by metal chelation - Chelating agents for Hg, Pb, Cd, As toxicity. Drugs that act by binding at the metal sites of Metalloenzymes. Chemotherapy: Chemotherapy with compounds of certain non-essential elements. Platinum complexes in cancer therapy – Cisplatin and its mode of action and side effects: – Cytotoxic compounds of other metals – Gold containing drugs as anti-rheumatic agents and their mode of action - Lithium in Psychopharmacological drugs. Radiopharmaceuticals – Technetium. Metal complexes in diagnosis-gold complexes in magnetic resonance imaging (MRI). Introduction to nanomedicine and applications. **[15 hrs]**

References:

1. Inorganic Reactions Mechanism,J. O. Edwards and W. A. Benjamin, INC, New York, (1965).
2. C. H. Langford and H. B. Gray, Ligand Substitution Processes, W. A. Benjamin, New York, (1966).
3. Mechanism of Inorganic Reactions, 2nd Edition, F. Basolo and R. G. Pearson, Wiley, New York, (1967).
4. Mechanisms of Inorganic Reactions, D. Katakis and G. Gordon, John Wiley & Sons, New York, (1987).
5. Kinetics and Mechanism of Reactions of Transition Metal Complexes, 2nd Edition, R. G. Wilkinns, VCH, Weinheim, (1991).
6. Reaction Mechanisms of Inorganic and Organometallic Systems, R. B. Jordan, Oxford University Press, Oxford, (1998).
7. Inorganic and Organometallic Reaction Mechanisms, 2nd Edition, J. D. Atwood, Wiley-VCH, Weinheim, (1997).
8. Fundamental Chemical Kinetics – An Explanatory Introduction to the Concepts, M. B. Wright, Harwood Publishing, Chichester, (1999).
9. Chemical Kinetics and Inorganic Reaction Mechanisms, 2nd Edition, S. Asperger, Springer, London, (2012).
10. Homogeneous Catalysis, G. W. Parshall, Wiley, New York, (1980).
11. Heterogeneous Catalysis in Practice, C. N. Satterfield, McGraw-Hill, New York, (1980).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ301	CO1	2	1	3	3	2	2			1	2	3	3	2
	CO2	4	3	2	2	2	1			1	2	3	3	2
	CO3	2	2		3	3	1			1	2	3	3	3
	CO4	4	3	1	2	2	1			1	2	4	3	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ302	ORGANOMETALLICS	HC	4	0	0	4	4

Course Objectives:

After successful completion of this course, the student will be able to:

i. To provide knowledge on typical organometallic reactions, the use of organometallic reagents in catalysis and organic synthesis,

ii. The deep focus on structure and bonding properties and reactivity of main group organometallics (including Grignard reagents, organolithium reagents, organophosphorus compounds, etc.) Organo transition metal chemistry and organometallic catalysis.

iii. The constructive components will aim to develop skills in the handling of air-sensitive compounds using the Schlenk technique and the purification of compounds using chromatographic techniques.

iv. Also provide orientation about industrial applications for organometallic chemistry.

Course Outcomes:

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

CO1. Analyze the bonding modes, stability and determine reactivity for ligands in organometallic complexes and their applications.

CO2. Recognize the typical organometallic reactions, explain their mechanisms and interpret them reactivity based on the structure.

CO3. Correlate the importance of number of homogenous and heterogenous catalysis reactions of organometallic compounds in industries and environment e.g. hydrogenation, hydroformylation and polymerization.

CO4. Defend, detect and exemplify organometallic applications in novel organic synthesis, pharmaceutical compounds and in conversion processes in petrochemical and energy industries

Course Content:

UNIT-I

Organometallic Chemistry 1: Compounds with transition metal to carbon bonds: classification of ligands, nomenclature, Bonding: Ionic vs Covalent model, MOT back bonding and eighteen electron rule; Counting electrons in complexes, Hapticity, Limitations of 18-electron rule, Oxidation states stability, transition metal carbonyls: range of compounds and structure, bonding, Inner and outer sphere coordination, Polynuclear carbonyl complexes, vibrational spectra of metal carbonyls, preparation, reactions; transition metal organometallics: square planar complexes, Carbonylates, Carbonyl hydrides, Ligands similar to CO, Non aromatic metal alkyls, Metal carbenes, metal alkylidenes and metal alkylidynes; Bridging alkyls, Structure

and bonding: metal-olefin bond and arene metal bond MO approach. Nitrogen activation.

UNIT-II

Organometallic Chemistry 2: Compounds with ligands having extended pi systems: cyclic pi systems, bis(cyclopentadienyl) compounds, MO of metallocenes, cyclopentadienyl carbonyl compounds, bis(arene) compounds, arene carbonyl compounds; isolobal analogy, Extensions of analogy, Applications of the analogy metal-metal multiple bonds, Metal-carbonyl-metal bonds, transition metal clusters; clusters and catalysis; hydride and dihydrogen complexes; bridging hydrides, Non carbon ancillary ligands, Phosphines, organometallic fluxionality.

UNIT-III

Organometallic Chemistry 3: Organometallic reactions and catalysis: Ligand dissociation and substituition – stereochemical aspect, Ligand cone angles, Redox effects, oxidative addition, reductive elimination, Nucleophiles activity, Nucleophilic and electrophilic attack of coordinated ligands, carbonalyte anions, insertion, hydride elimination, abstraction; Catalysis : Homogenous and heterogenous catalysis, alkene hydrogenation, Tolman catalytic loop, Synthesis gas, hydroformylation, Wacker process, Ziegler-Natta polymerisation, cyclo oligomerisation, olefin isomerisation, olefin metathesis, Monsanto acetic acid synthesis, Fischer-Tropsch process, hydrosilylation. Organometallic Nitrogen fixation.

UNIT-IV

Organometallics Chemistry 4: Chemistry of Organolithium, Organomagnesium, Activity of Nucleophiles, Organoboranes, organosilicon and selected transition metal compounds, copper complexes, Vasaka complex, Bonding of Pd and Rh with olefins applications in C-C , C-N bond formations, Heck reaction, Carbonylation, hydroformylation, olefin isomerism, arylation, aryl amination using Pd reagents, olefin metathesis, Stille coupling, Sonogashira reaction, Buchwald reaction and Pauson -Khand reaction. Surface supported organometallic catalysts. Asymmetric catalysis, Organometallics in medicinal applications.

References:

1. P. Powell, Principles of Organometallic Chemistry, ELBS, 2nd Edition, (1991).
2. J. E. Huheey, Inorganic Chemistry, 3rd Edition, Harper International, (1983).
3. M. F. Purcell, J.C. Kotz, Inorganic Chemistry, Saunder, (1977).
4. A F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 5thEdition, JohnWiley.
5. J. Clayden,N. Greeves, S.Warren, Organic Chemistry, Oxford University press, 2ndEdition, (2012).
6. Gary L. Miessler, Donald A. Tarr, Inorganic Chemistry, Pearson publishers.
7. Robert H. Crabtree, The organometallic chemistry of transition metals, Wiley Interscience.

3. Didier Astruc, Organometallic Chemistry and Catalysis, Springer.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ302	CO1	2	2	1	2	2	1			1	1	3	1	2
	CO2	2	2	1	2	1	1			1	1	2	1	2
	CO3	2	1	1	2	1	2			2	1	2	1	2
	CO4	2	1	1	1	1	2			2	2	2	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ303	SOLID STATE CHEMISTRY AND ADVANCED MATERIALS	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Introduction to solid state chemistry is one semester college course on the principles of chemistry.

ii. The unique and popular course satisfies the general degree requirement, with an emphasis on solid-state materials and their application to engineering systems.

iii. Enroute with an exploration of the fundamental relationship between electronic structure, chemical bonding and atomic order, then proceed to the chemical properties of "aggregates of molecules", including crystals, metals, glasses, semiconductors, solutions and acid-base equilibria, polymers, and biomaterials.

iv. Real-world examples are drawn from industrial practice (e.g. semiconductor manufacturing), energy generation and storage (e.g. automobile engines, lithium batteries), emerging technologies (e.g. photonic and biomedical devices) and the environment impact of chemical processing (e.g. recycling glass, metal and plastic).

Course Outcomes:

By the completion of course student will be able to

CO1. Predict the properties and interactions of chemical substances by understanding their composition at the atomic level, making connections to structure, bonding, and thermodynamics as necessary.

CO2. Reflecting and reviewing the principles of materials science (specifically microstructure design and selection) to the selection of materials for specific engineering applications.

CO3. Assess the quality of text and graphics in textbooks and other published sources, and understand the advantages and limitations of different models proposed to explain each concept.

CO4. Summarize and identify the similarities and differences among important classes of materials including glasses, metals, polymers, biomaterials, and semiconductors.

Course Content:

UNIT-I

The solid state: Types of solids, Bonding in solids, isomorphism and polymorphism, laws of crystallography, lattice types, lattice energies, Packing efficiencies, X-ray diffraction, Bragg's equation, Miller indices, Bragg Method, Experimental methods-powder and rotating crystal methods, indexing of powder and rotating crystal photographs.Debye Scherrer method of X-ray structure analysis of crystals,

indexing of reflections, identification of unit cells from systematic absence in diffraction pattern, structure of simple lattice and X-Ray intensities, structure factor and its relation to intensity and electron density, phase problem, procedure for an X-ray structure determination. Defects in crystals, Stoichiometric imbalance in crystals. **[15 hrs]**

UNIT-II

Solid State Reactions: General principle, nucleation and growth process of crystals, types of reactions: Additive, structure sensitive, decomposition and phase transition reactions, tarnish reactions, kinetics of solid state reactions, factors affecting the reactivity of solid state reactions. Methods of Single Crystal Growth Solution growth; Melt Growth-Bridgeman, Czochralski, Kyropoulus, Chemical Vapour Transport; plasma enhanced deposition, catalytic chemical vapour deposition, arc discharge method,Fused Salt Electrolysis; Hydrothermal method; Flux Growth. **[15 hrs]**

UNIT-III

Electronic Properties and Band Theory: Metals, insulators and semi-conductors, free electron theory and its applications, electronic structure of solids, band theory, band structure of metals, insulator, and semiconductors, doping in semiconductors, photoactive semiconductors, Junction Properties: Metal-metal junctions, metal-semiconductor junctions, p-n junctions, industrial applications of semiconductors: mixed oxides, spinels and other magnetic materials. Super conductors:Meissner effect, type I and II super conductors, isotope effect, basic concepts of BCS theory, manifestations of the energy gap,ionic conductivity in solids, diffusion, drift conductivity, optical properties of solids, photo-conduction and photoelectric effects, laser action, solid state laser and their applications. Thermal conductivity in metals, semiconductors and insulators. **[15 hrs]**

UNIT-IV

Advanced materials: Advanced semiconductor materials, electronic materials, solar energy conversion materials, Photonics and spintronics materials, solid state structural aspects - electrode materials in electrochemical energy conversion devices, solid state electronic and Ionic conductors, Thermo electric and piezoelectric, perovskites, Superconducting materials, Photoluminescent materials, Inorganic-organic hybrid materials:Synthesis of metal oxides and its composite nanoparticles by sol-gel, solvothermal and hydrothermal method.Porous materials: Hard and soft template methods : Carbonaceous materials, metal oxides. **[15 hrs]**

References:

1. A guide to laser in chemistry, Gerald R., Van Hecke, Keny K. Karokitis.

2. Principals of solid state, H. V. Keer, Wiley Eastern.
3. Solid state chemistry, N. B. Hannay.
4. Solid state chemistry, D. K. Chakrabarty, New Age International.
5. An Introduction to Crystallography, F. G. Philips.
6. Crystal Structure Analysis, M. J. Buerger.
7. The Structure and properties of materials, Vol. III, Electronic properties, John Walss.
8. Electronic processes in materials, L. U. Azroff and J. J. Brophy.
2. Chemistry of imperfect crystal, F. A. Krogen.
3. Elements of X-ray Diffraction, B. D. Cullity, Addison, Weily.
4. Solid state Chemistry, A.R.West (Plenum).
5. Electronics made simple, Jacobwitz. Paper: PCH: 304 B: Advanced Chemical Kinetics (Elective).

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21SM Z303	CO1	2	2			1	2	2		1	2	3	1	1
	CO2	2	2	2	2	3	2	2	2	1	2	2	3	1
	CO3	2	2	2	3	2	1	2	2	2	2	2	2	1
	CO4	2	2	3	2	3	2	2	2	1	3	2	3	1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ304	STRUCTURAL METHODS IN INORGANIC CHEMISTRY-III	HC	4	0	0	4	4

Course objectives:

This course aims to provide the student to

i. Demonstrate the knowledge of the basic concept of spectroscopy laser, optical spectroscopy, mechanism of fluorescence.

ii. Explore understanding of photoelectron spectroscopy (PES) and electron energy loss spectroscopy for chemical analysis and other most important applications.

iii. Create broad advanced techniques knowledge of SEM, SAM, SPM, STM, LEED, TEM, ASS and ICPMS for structure and chemical analysis applications.

iv. Acquire knowledge of non-destructive techniques for various metals, product analysis, effects and other applications.

Course outcomes:

By the completion of course student will be able to

CO1. Basic spectroscopy, laser, mechanism fluorescence.

CO2. Applications, electron spectroscopy, chemical analysis.

CO3. Advanced techniques, applications, analysis.

CO4. Analysis, applications, effects chemical reactions.

Course Content:

UNIT-I

Basic concept of spectroscopy: Overview of basic concepts: Light-matter interaction, transition dipole moment, selection rules for electronic transitions.

Laser: Einstein coefficients, introduction to lasers, application of lasers in spectroscopy.

Molecular luminescence spectroscopy: Basic principles of fluorescence and phosphorescence, excitation and deactivation processes (energy level diagram), factors affecting fluorescence and phosphorescence, quenching of fluorescence, fluorescence (or phosphorescence) intensity, fluorescence and chemical structure, instrumentation for fluorimetry and phosphorimetry, application of fluorimetry and phosphorimetry, fluorescent indicators,comparison between fluorimetry and phosphorimetry, chemiluminescence, spectral studies of some inorganic complexes.

[12 hrs]

UNIT- II

Advanced optical Spectroscopy: Surface plasmon spectroscopy, multiphoton spectroscopy, single-molecule spectroscopy, and applications.

Electron spectroscopy: Principle, working, components, instrumentation and applications in chemical analysis.

Electron energy loss spectroscopy: Principle, working, components, instrumentation, and applications for chemical analysis.

[12 hrs]

UNIT - III

Imaging and Depth Profiling techniques: basic principle, instrumentation and application of scanning electron microscopy (SEM); secondary Auger microscopy (SAM); scanning probe microscopy (SPM); scanning tunneling microscopy (STM); transmission electron microscopy (TEM); low energy electron diffraction (LEED).

Destructive techniques: Basic principle, instrumentation and application of Atiomic absorption spectrocopy AAS, inductively coupled plasma-atomic emission spectroscopy (ICP-AES). **[12 hrs]**

UNIT-IV

Non-destructive techniques: Basic principle, instrumentation and application of Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy (TDS).

Structure characterization of any advanced materials by Fluorescence Spectra, XPS, EELS, SEM, AFM, STM, TEM, HR-TEM, IC-AES, EDS, XANES, SIMS, TPD and TDS.

[12 hrs]

References:

1. Modern Spectroscopy, 4th Edition, J. M. Hollas, John Wiley & Sons, (2004).
2. Modern Optical Spectroscopy, Student Edition, William W. Parson, Springer, (2009).
3. Fundamentals of Photochemistry, K. K. Rohatgi-Mukhejee, Wiley Eastern Ltd, (1992).
4. Principles of Fluorescence Spectroscopy, 3rdEdition,J. R. Lakowicz, Springer, (2006).
5. Laser Spectroscopy- Basic concepts and instrumentation, 3rdEdition, W. Demtroder, Springer,(2004).
6. Scanning Probe Microscopy and Spectroscopy, R. Wiesendanger, Cambridge University Press, (1994).
7. Handbook of instrumental techniques for analytical chemistry, Frank A. Settle, Prince Hall, New Jersey, (1997).
8. Foundations of catalysis and nanoscience, K. W. Kolasinski John Wiley and Sons, West Susses, (2002).

9. Physics at Surfaces, A. Zangwill, Cambridge Univ. Press, (1988).
10. Introduction to Surface Chemistry and Catalysis, G.A. Somorjai, Y. Li, Wiley, (2010).
11. Physical chemistry of surfaces, Arthur W. Adamson (1990).
12. The chemical physics of surfaces, Roy S. Morrison, S. Roy, (1990).
13. Modern techniques of surface science, D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, (1994).
14. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, New York, (1993).

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21SM Z304	CO1	2	1		3	1						2	3	1
	CO2	3			3	1						3	3	1
	CO3	3			3	1						2	3	1
	CO4	3			3	1						2	3	1

SEMESTER-III: INORGANIC CHEMISTRY SOFT CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS301	INDUSTRIAL INORGANIC CHEMISTRY-III	SC	2	1	0	3	4

Course Objectives:

This course aims to provide the student to

i. Conclude the preparation of some industrial inorganic products and challenges in the production.
ii. Defend the following topics: Sulfur industry, Nitrogen based industrial products, inorganic solvents, mineral fertilizers, industrial and domestic water production, industrial gas productions, inorganic solids, cement, glasses and pigments.
iii. Appraise the importance of inorganic chemical industry, their economic impact, individual chemical processes and production challenges.
iv. Develop practical skills to synthesis of industrial inorganic compounds by the acquired knowledge.

Course Outcomes:

By the completion of course student will be able to

CO1. Illustrate the basic chemical process involved in the production of major commercial products in industrial Inorganic chemistry.
CO2. Conclude the operation and solve problems relating to the production process in industrial inorganic chemistry, written and verbal.
CO3. Evaluate the product in industrial production by the suitable technique.
CO4. Analyze environmental issues pertaining to the chemical industry.

Course Content:

UNIT-I

Materials in Catalysis- Introduction: Basics of catalysis, Fundamental properties of the solid catalysts. Classification of solid catalysts, Metals and metallic alloys. Preparation of metallic catalysts. Structure. Specific features of metallic catalysts. Structure sensitivity of catalytic reactions. Structure of adsorbate layers; Stepped surfaces; Surface relaxation and reconstruction of surfaces; homogeneous and heterogeneous catalytic surfaces Supported metal catalysts. Metal-support interaction. Reaction mechanisms in catalysis on metals. Fundamentals of kinetics of heterogeneous catalytic reactions. Case study: the ammonia synthesis catalyst and the reaction mechanism involved. Noble metal catalysis

[7 hrs]

UNIT-II

Heterogeneous Catalysis and porous materials: Classification of solid catalysts, Adsorption of molecules at the solid surfaces, Adsorbed states of molecules on metals, potential-energy curves for adsorption, descriptive chemistry of chemisorption on metals, chemisorption and catalysis by metals quantitative aspects, catalysis by unsupported and supported bimetals, Adsorption and catalysis on semiconducting oxides, selective oxidation of hydrocarbons. Different types of reactors.

Zeolite Compounds and Heterogeneous Catalysis: Introduction to porous materials: Classification into micro-, meso- and macro porous materials, the origin of pores and its significance, distinction from condensed materials. **[8 hrs]**

UNIT-III

Semiconducting materials in electronics and energy devices, Semiconductors, Binary and ternary oxides and non-oxide semiconductors, their structure, properties, doping, band structure modification and working application in solar energy conversion, electronic components, semiconductor.

Materials for Sensors: Thermal, Gas, Biosensors types, sensors and applications.

Chemistry of silicates and Hard materials: Glass, alkali silicates, composition, manufacture, raw materials, properties. Ceramics: classification of ceramic products, manufacture of ceramics, clay, Oxide ceramics, aluminum oxide, zirconium oxide, beryllium oxide, uranium oxide and thorium oxide, other oxide ceramics, electro- and magneto-ceramics and their structure and properties.

[7 hrs]

UNIT-IV

Inorganic polymers, Surfactants, Biosensors, Pesticides: Chemistry of Inorganic polymers: Poly-(sulphur –nitrides), Polyphosphates, polysilicates, polysilicones, organo-metallic polymers, bonding, structure and properties, Inorganic fibers.

Surfactants: Classification with examples, Adsorption and micelle formation, Manufacture of anionic, cationic, zwitterionic and nonionic detergents, Applications as Foaming agent, Wetting agent, Dispersant, Solubilizers, Emulsifiers and Rheology modifiers, Detergent formulations, Detergent biodegradation, Biosurfactants.

Inorganic Pigments: white pigments, titanium dioxide pigments, zinc sulfide pigments, colored pigments.

Pesticides: Introduction, classification, synthesis of few common pesticides of chlorinated (DDT, BHC, Chlordane, Aldrin), organophosphorus and carbamate (parathion, Malathion, carbaryl) compounds family. **[7 hrs]**

References:

1. Chemical Process Industries, 4th Edition, Norris Shreve, R. and J.A. Brink Jr. McGrawHill, Tokyo, (1977).
2. Industrial Chemistry, Chakrabarty, B.N Oxford & IBH Publishing Co., New Delhi (1981).
3. Industrial Inorganic Chemistry, Karl Heinz Büchel, Hans-Heinrich Moretto, Dietmar Werner, 2nd Completely Revised Edition, Wiley – VCH, (2008).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS301	CO1	2	1	2			1			1	1	2		1
	CO2	1	1	1			1	1		1	1	2		1
	CO3	1		1		1	2	1	1	1	1	2		
	CO4	1	1	1		1	1	1	1	1	1	1		

SEMESTER-III: ORGANIC CHEMISTRY HARD CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ307	ADVANCED ORGANIC CHEMISTRY-III.1	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Enhance the knowledge on structure and reactivity of organic molecules with emphasis on reaction mechanisms.
ii. Examine the principles of bonding, stereochemistry, kinetics and thermodynamics in organic synthesis.
iii. Evaluate the logical disconnections to identify the synthons and choose the reactants and reagents.
iv. Explore the feasibility of a process in terms of cost, conditions and starting materials.

Course Outcomes:

By the completion of course student will be able to

CO1. Interpret the mechanisms of organic reactions and identify the synthons.
CO2. Develop a detailed understanding for appropriate disconnections and possible strategies.
CO3. Enhance the knowledge on various feasible reactions for synthesizing molecules.
CO4. Justify the regioselectivity, stereoselectivity and chemoselectivity of reactions.

Course Content:

UNIT – I

The Disconnection Approach, Basic Principles: Synthons and Reagents, Synthesis of Aromatic Compounds, Strategy I: The Order of Events, One-Group C-X Disconnections, Strategy II: Chemoselectivity, Two-Group C-X Disconnections, Strategy III: Reversal of Polarity, Cyclisations, Amine Synthesis, Strategy IV: Protecting Groups, One-Group C-C Disconnections I: Alcohols. **[15 hrs]**

UNIT – II

General Strategy A: Choosing a Disconnection, Strategy V:Stereoselectivity A, One-Group C-C Disconnections II: Carbonyl Compounds, Strategy VI: Regioselectivity, Alkene Synthesis, Strategy VII: Use of Acetylenes, Two- Group C-C Disconnections I: Diels-Alder Reactions, Strategy VIII: Introduction to Carbonyl Condensations, Two-Group C-C Disconnections II: 1,3-Difunctionalised Compounds Strategy IX: Control in Carbonyl Condensations. **[15 hrs]**

UNIT – III

Two Group C-C Disconnections III:1,5-Difunctionalised Compounds, Michael Addition and Robinson Annelation, Strategy X: Aliphatic Nitro Compounds in Synthesis, Two-Group Disconnections IV: 1,2-Difuntionalised Compounds, Strategy XI: Radical Reactions in Synthesis, Two-Group Disconnections V: 1,4-Difunctionalised Compounds, Strategy XII: Reconnection, Two-Group C-C Disconnections VI: 1,6-Dicarbonyl Compounds, General Strategy B: Strategy of Carbonyl Disconnections, Strategy XIII: Introduction to Ring Synthesis: Saturated Heterocycles, Three- Membered Rings. **[15 hrs]**

UNIT – IV

Strategy XIV: Rearrangements in Synthesis, Four-Membered Rings: Photochemistry in Synthesis, Strategy XV: The Use of Ketenes in Synthesis, Five-Membered Rings, Strategy XVI: Pericyclic Reactions in Synthesis, Six-Membered Rings, General Strategy C: Strategy of Ring Synthesis, Strategy XVII: Stereoselectivity B, Aromatic Heterocycles, General Strategy D: Advanced Strategy. **[15 hrs]**

References:

1. Organic Synthesis: The Disconnection Approach, 2nd Edition, Stuart Warren, Paul Wyatt, Wiley, Chichester, (2008).
2. Organic Chemistry from Retrosynthesis to Asymmetric Synthesis, 1st Edition, Vitomir Šunjić, Vesna PetrovićPeroković, Springer, Switzerland, (2016).
3. Organic Mechanisms, 2nd Edition, Reinhard Bruckner, Springer-Verlag, Berlin, (2010).
4. Organic Chemistry, 2nd Edition, Jonathan Clayden, Nick Greeves, Stuart Warren, Oxford University Press, Oxford, (2012).
5. Modern Methods of Organic Synthesis, 4th Edition, William Carruthers and Iain Coldham, Cambridge University Press, Cambridge, (2004).
6. Name Reactions, 3rd Edition,Jie Jack Li, Springer-Verlag, Berlin, (2006).
7. Introduction to Strategies for Organic Synthesis, 1st Edition, Laurie S. Starkey, Wiley, New Jersey, (2012).
8. Organic Synthesis: Strategy and Control, 5th Edition, Paul Wyatt, Stuart Warren, Wiley, Chichester, (2007).
9. March's Advanced Organic Chemistry, 7th Edition, Michael B. Smith, Wiley, New Jersey, (2013).

Mapping of Course Outcomes with Programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ307	CO1	3	1	2	1	2	3	1			1	2	1	2
	CO2	2	1	2	2	2	1	2			1	2	2	3
	CO3	2	2	1	1	3	2	3			1	3	1	2
	CO4	3	2	2	1	2	1	2			1	2	2	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ308	ADVANCED ORGANIC SYNTHESIS-III.2	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. The advanced lineup in organic synthesis provides a deeper understanding of the reactivity and properties of the organic compounds and emphasis on the applications of important reagents and reactions in organic synthesis.

ii. Expand a fundamental understanding of carbon-carbon single and double bond formation.

iii. Development of highly stereoselective reactions and their applications in complex synthesis. These reactions include stereoselective alkylation of carbonyl compounds, stereoselective aldol condensations, stereoselective oxidations, epoxidations and reductions.

iv. Discussion of newer methods for the stereoselective formation of carbon-carbon double bonds, and the modern application of the Diels Alder reaction, particularly its use in the control of stereochemistry in the synthesis of natural products.

v. Determine which strategic bond constructions can be used most effectively to obtain synthetic targets with high selectivity.

Course outcome:

By the completion of course student will be able to

CO1. Analyze Molecular Orbital (HOMO-LUMO) symmetry concepts and pericyclic reactions.

CO2. Differentiate the products by photochemical and thermal reactions.

CO3. Knowledge of name reactions in organic synthesis and their applications.

CO4. Utilize the principles behind enantioselectivity and Diastereoselective in organic synthesis.

Course Content:

UNIT-1

Pericyclic Reactions: Introduction, Classification of pericyclic reactions.Electrocyclic reactions: con rotation and dis rotation. Electrocyclic ring closure and opening in 4n and 4n+2 systems. Cycloaddition Reactions: Suprafacial and Antarafacial additions in 4n and 4n+2 cycloadditions. Sigmatropic reactions: [i-j] shifts- suprafacial and Antarafacial shifts, Cope and Claisen rearrangement reactions. Molecular orbitals: ethylene, 1,3-butadiene, 1-allyl cation. Frontier Molecular Orbital (HOMO-LUMO) approach-concept: Framing Woodward Hofmann selection rules for all the pericyclic reactions by Frontier Molecular Orbital (FMO) approach. Conservation of orbital symmetry: (Correlation Diagrams) approach- for electrocyclic and cycloadditions. **[15 hrs]**

UNIT-2

Photochemistry: Introduction, Laws of photochemistry, Quantum yield, Photochemical equivalence Photochemistry of (n-π*) Transitions: Excited states of carbonyl compounds, homolytic cleavage of α-bond. Norrish type-I reactions in acyclic and cyclic ketones and strained cycloalkane ketones. Norrish type II reactions in ketones and esters. Paterno-Buchi reaction and Barton reaction.

Photochemistry of π-π* Transitions: Excited states of alkenes, cis-trans isomerization, and photo stationary state. Photochemistry of 1,3-butadiene. Electrocyclization and sigmatropic rearrangements, di-π methane rearrangement. Intermolecular reactions, photocycloadditions, photodimeriastion of simple and conjugated olefins. Addition of olefins to α, β-unsaturated carbonyl compounds. Photoisomerization of benzene.

[15 hrs]

UNIT-3

STEREOCHEMISTRY-II

Optical activity in the absence of chiral atoms: Atropisomerism, chirality in biphenyls, allenes, BINAP (2,2′-bis(diphenylphosphino)-1,1′-binaphthyl), adamantanes, ansa compounds, cyclophanes, *trans*-cyclooctene, catenanes, rotaxanes and helicenes. Assignment of R, S- configuration to these classes of compounds.

Optical activity due to the presence hetero atoms: Chirality of organic compounds due to the presence of silicon, nitrogen, phosphorous, arsenic and sulphur atoms. Determination of R,S-configuration of these compounds using CIP rules.

Determining absolute and relative configuration

i). Chemical correlation of configuration: Methods without involving the chiral centre. Chemicaltransformation involving the chiral centre. Chemical correlation involving diastereomers.

ii). Methods based on comparison of optical rotation: Distance rule, Rule of shift, Rule of optical superposition, Mill's rule, Method based on molecular rotation difference.

iii) The method of quasi-racemate.

iv). Use optical rotatory dispersion curves: α-axial haloketone rule and its applications, octant rule (application of these rules in the determination of absolute configuration of substituted cyclohexanones, decalones and cholestanones). **[15 hrs]**

UNIT-4

Asymmetric Synthesis: 'ee' and methods of determination of 'ee'.

Stereoselectivity: classification, terminology and principle. Asymmetric synthesis and asymmetric induction. Double diastereoselection and double asymmetric induction.

Acyclic stereoselection: Addition of nucleophiles to carbonyl compounds (1,2- 1,3- and 1,4-asymmetric induction). Asymmetric aldol condensation. Addition of allyl metal and allyl boranes to carbonyl group.

Diastereoselection in cyclic systems: Nucleophilic addition to cyclic ketones (formation of axial and equatorial alcohols, catalytic hydrogenation, alkylation, diastereoselective oxidations and stereoselective cyclization of poylenes).

Enantioselective synthesis: Reduction with chiral hydride donors [(S)-PBMgCl, (-)- $iBOAlCl_2$, alpine-borane, (S)-BINAL-H, (R,R)-DIOP, and (S,S)-CHIRAPHOS]. Enantioselective reactions: alkylation of ketones via hydrazones, alkylation with chiral PTC, Michael addition and intramolecular aldol condensation. Use of (+)- and (–)- DET in asymmetric epoxidation. Polymer-bound chiral catalysts in asymmetric induction. Asymmetric amplification. **[15 hrs]**

References:

1. Principles of Organic synthesis, 3rdedition,Richard O.C. Norman and James M Coxon, CRC Press, (1993).
2. Advanced organic chemistry, 4thEdition,J. March, John Wiley, 2008.Organic synthesis, R.E.Ireland, Prentice-hall India, New Delhi, (1975).
3. Understanding organic reaction mechanisms, A. Jacob, Cambridge Univ Press, (1997).
4. Introduction to organic chemistry, A. Streitweiser, Jr and C. H. Heathcock, Macmillan, (1985).
5. Physical and mechanistic organic chemistry, 1stEdition,R. A.Y. Jones, Cambridge Univ Press, (1979).
6. Modern synthetic reactions, 2ndEdition, H. O. House, W. A. Benjamin, California, (1972).
7. Some modern methods of organic synthesis, 2ndEdition, W. Carruthurs, Cambridge Univ. Press, London, (1978).
8. Mechanisms of molecular migration, Vols I & II, B. S. Thyagarajan, Pergamon Press, Oxford, (1979).
9. Comprehensive organic chemistry, D. Barton and W. D. Wallis, Pergamon Press, Oxford, (1983).
10. Organic chemistry,6thEdition,Vol. II, I. L. Finar Longman, (1992).
11. Organic reaction Mechanisms, 3rdEdition., V. K. Ahluwalia and R. K. Prashar, Narosa, New Delhi, (2005).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM Z308	CO1	3	3		1	3	1	2		1	2	3	2	2
	CO2	1	1	1	1	3	2	2		1	2	4	2	2
	CO3	1	2		2	3	1			1	2	1	2	2
	CO4	1	3		2	3	1	2		1	2	1	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ309	NATURAL PRODUCTS AND BIOORGANIC CHEMISTRY-III.3	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. To identify, extract and eventual modification of compounds that are of natural origin- plants, animals and bacteria for pharmaceutical use and other purposes
ii. To bring the awareness of the richness and diversity of plants and animals around them.
iii. To distinguish the naturally occurring compounds into different classes
iv. To formulate different reactions and their mechanism in the natural product synthesis.

Course Outcomes:

By the completion of course student will be able to

CO1. Acquire the knowledge of Identifying and characterizing various classes of natural products by their structure Appreciate the biogenesis of many natural products of importance.

CO2. Contribute the knowledge of natural products in drug design and development of new drugs with hemisynthetic routes or with total synthesis.

CO3. Discuss the use of natural products as starting materials for medicine.

CO4. Carry out independent investigations of plant materials and natural products.

Course Content:

UNIT-I

Terpenoids and Carotenoids: Classification, nomenclature, occurrence and isolation. Isoprene rules. Stereochemistry of citral, farnesol, limonene, 1,8-cineole, menthols and borneols. Correlation of configurations of terpenoids. Structure elucidation of camphene, -pinene, caryophyllene and santonin. Synthesis and biosynthesis of the following: Linalool, terpineol, fenchone, eudesmol, abietic acid. Commercial synthesis of camphor. Biosynthesis of squalene and cyclisation of squalene into lanosterol and friedelene.

Carotenoids: Methods of isolation. Structural relationship of α-, β- and γ-carotenes. Structure elucidation and synthesis of β-carotene. **[15 hrs]**

UNIT-II

Alkaloids: Definition, nomenclature, occurrence, isolation, classification, General methods of structure elucidation. Synthesis and biosynthesis of the following alkaloids: Ephedrine, hygrine, coniine and cocaine. Cinchona alkaloids: Cinchonine and quinine. Opioid alkaloids: Morphine, codeine, thebiene and heroin. Structure elucidation and synthesis of papaverine and ergotamine. Photochemical synthesis of nuciferine, coradyline and tylophorine. **[15 hrs]**

UNIT-III

Steroids: Occurrence, nomenclature, basic skeleton, Diels hydrocarbon and stereochemistry. Isolation, structure and structural elucidation of sterols and bile acids (determination of ring size, nature of side chain, position of angular methyl and stereochemistry of ring junctions). Sex hormones and corticosteroids. Synthesis of cholesterol, estrone, progesterone, androsterone, testosterone. Photo products of ergosterol-vitamins D. Barton reaction for the synthesis of aldosterone, epiandrosterone. Marker degradation.

Porphyrins and vitamin B12: Structure elucidation and synthesis of haemin and vitamin-B12 (synthesis of Vitamin-B12 from cobyric acid). **[15 hrs]**

UNIT-IV

Amino acids and Peptides: Synthesis of amino acids, Sanger and Edman methods of sequencing. Cleavage of peptide bond by chemical and enzymatic methods. Peptide synthesis- Protection of amino group (Boc-, Z- and Fmoc-) and carboxyl group as alkyl and aryl esters. Use of DCC, EEDQ, HATU, HOBt and active esters, acid halides, anhydrides in peptide bond formation reactions (introduction to new generation coupling agents like COMU, Oxyma, T3P). Deprotection and racemization in peptide synthesis. Solution and solid phase techniques. Synthesis of oxytocin and enkephalins. Peptidomimetics-Introduction and examples.

Insect pheromones: Introduction, classification. Pheromones in pest control. Syntheses of (one synthesis should be stereoselective synthesis) I) Grandisol (component of boll weevil pheromone) ii) Farenal (trail pheromone of pharaoh's ants) iii) Brevicomin (pheromone from Dendroitis brevicomis) iv) (+)-Disparlure (gypsy moth sex pheromone). v) 3,11-Dimethy1-2-nonacosanone (pheromone of German cockroaches). vi) Bombykol (sex pheromone of silkworm moth). vii) Multistriatin (Elm bark beetle sex pheromone).

[15 hrs]

References:

1. Natural products: Their chemistry and biological significance, J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthorpe & J. B. Harborne, Longman, UK, (1994).
2. Terpenes, J. Verghese, Tata McGraw-Hill, New Delhi, (1982).
3. Chemistry of terpenes and terpenoids, A. Newman, Academic Press, London, (1975).
4. Handbook of naturally occurring compounds, Vol. II: Terpenes, T. K. Davon, A. I. Scott, Academic Press, NY, (1972).

5. Natural products chemistry, Vol. I & II, K. Nakanishi, T. Goso, S. Ito, S. Natori & S. Nozoe, Academic Press, NY, (1974).
6. Total synthesis of natural products, Vol. I & VI, Apsimon, John Wiley, NY, (1973-1981).
7. Organic chemistry, Vol.II, I. L. Finar, 6thEdition. Longman, (1992).
8. Chemistry of natural products, 6th Edition, Vol. I & II, O. P. Aggarwal, Goel Publishing House, (1982).
9. Total synthesis of natural products: The chiral approach, Vol.III, S. Hanessian Pergamon Press, (1983).
10. Total synthesis of steroids, Akhaun & Titov, Jerusalem, (1969).
11. Medicinal natural products: A biosynthetic approach, P. M. Dewick. John Wiley, Chichester, (1997).
12. The colours of life: An introduction to the chemistry of porphyrins and related compounds, L. R. Milgrom, Wiley Chichester, (1995).
13. Interpretation of the UV spectra of natural products, A.I. Scott, Pergamon Press, Oxford, (1964).
14. Spectral data of natural products Vol. I., K.Yamaguchi, Elsevier Publishing Co, London, (1970).
15. Chemistry of natural products: A unified approach, N. R. Krishnaswamy, University Press, India, (1999).
16. Amino Acids, Peptides and Proteins in Organic Chemistry, Edited by Andrew B. Hughes, Volume 4, Wiley-VCH Verlag GmbH & Co. KGaA, ISBN: 978-3-527-32103-2, (2011).
17. Principles of Peptide Synthesis, Bodanszky M, Springer, ISBN 978-3-642-96763-4, (1984).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ309	CO1	3	2		1	2				1	1	3	2	2
	CO2	3	2	3	3	2				1	1	3	2	2
	CO3	2	2	3	2	2				1	1	3	2	1
	CO4	2	2	2	2	3	2			1	1	3	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ310	ORGANOMETALLICS IN ORGANIC SYNTHESIS-III.4	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Discuss the Complexation and De-Complexation Reactions of S and P- Bonded systems and use of Organo transition metal complexes as protecting and stabilizing groups.
ii. Illustrate the synthesis and applications of various organometallic reagents in organic synthesis.
iii. Explain the synthetic applications of tri methyl silyl chloride, Organo tin, Organo cerates, and Organo mercurial.
iv. Develop and design the catalytic cycle for the Homogeneous and Heterogeneous catalysis.

Course Outcomes:

By the completion of course student will be able to

CO1. Distinguish between Complexation and De complexation reactions of Organo transition metal complexes.
CO2. Apply the appropriate mechanistic steps in reactions involving organometallic compounds.
CO3. Apply organometallic reagents and reactions in organic synthesis.
CO4. Acquire the knowledge of fundamental organometallic reactions to construct catalytic cycle.

Course Content:

UNIT-I

Organometallic Compounds in Organic Synthesis-I: General introduction of Chemistry of Organo transition metal complexes, hapticity, types of Organometallic Compounds, 16 and 18 Electron rules. Synthesis, structure, bonding and reactivity of Carbene Complexes. Complexation and De-Complexation Reactions: σ-bonded systems and. π- bonded systems such as- olefins, acetylenes, allyl moieties, cyclobutadiene, cyclopenta dienyl moieties. Grubb's Ru Catalysts (metathesis). Use of Organo transition metal complexes as protecting and stabilizing groups: Protection of olefins, acetylenes. Stabilization of cyclobutadiene and norbornadienones. Organometallics as Electrophiles and nucleophiles: Nucleophilic addition to ή2, &ή5 complexes. Electrophilic addition to ή4, ή6 and Organometallics in coupling and cyclization reactions: Coupling and cyclization of organic nucleophiles with olefins (including Heck reaction) and coupling of olefins with acetylenes. **[15 hrs]**

UNIT-II

Organometallic Compounds in Organic Synthesis-II: Chemistry of Organometallic compounds: Synthesis and applications of Organo LiHMDS and LDA and Organo zincs: Preparation, reaction with compounds containing acidic protons, reaction with C-C multiple bonds, Simmons Smith, and Reformatsky reaction. Organo Copper Reagents: (Gilman reagents-lithium di alkyl cuprates): Preparation, reactions with alkyl, allyl, vinyl, benzyl and aryl halides, aldehydes, ketones (including a, b-unsaturated carbonyl compounds) and epoxides. Synthetic applications of Organo boranes: Preparation of Organo boranes viz hydroboration with BH3-THF, dicylohexyl borane, disiamyl borane, thexyl borane, 9-BBN and diisicamphenyl borne, functional group transformations of Organo Boranes-Oxidation. Formation of carbon-carbon-bonds viz Organo boranes carbonylation, and reaction of alkenyl boranes and tri alkenyl borates. **[15 hrs]**

UNIT-III

Organometallic Compounds in Organic Synthesis-III: Organo Silanes: Synthetic applications of tri methyl silyl chloride, silyl carbanion and β-silyl Carboniumions. Peterson olefination. Preparation and Synthetic applications of OrganoSamarium and Organo Chromium Compounds.Organo tin: Preparation and reactions of tri-n-butyl tin hydride, Barton decarboxylation and Barton- McCombie reaction.

Organo cerates: Preparation and reactions of Organo cerates, Organo mercurial: Preparation, Electrophilic substitution reactions, Solvomercuration-demercuration and cyclopropanation of alkenes. **[15 hrs]**

UNIT-IV

Homogeneous Catalysis: Introduction, properties of catalysis, types of reactions in homogeneous catalysis, hydrogenation of olefins, isomerization of olefins, Oxo-process, Wacker process, Monsanto acetic acid process, water gas shift reaction, carbonylation, alkene hydrosilylation.

Heterogeneous Catalysis: Introduction, Fischer-Tropsch reaction, Ziegler-Natta catalysis.

Fluxionality behavior in organometallic complexes: Fluxionality in complexes containing ή2 -Olefin, ή3- allyl and dienyl complexes. Applications of organometallic compounds in industry. **[15 hrs]**

References:

1. Organometallic Chemistry, R. C. Mehrotra and A. Singh, Wiley Eastern, (1991).
2. The Organometallic Chemistry of the transition metals, R. H. Crabtree, (1988).
3. Principles and application of the Organotrnsition metal chemistry, J. P. Collman, L. S. Hegedus, University Science books, (1980).
4. An introduction to Organometallic Chemistry, A.W. Parkinsand R.C.Poller, Macmillan, (1986).
5. Modern Synthetic Reactions, 2nd Edition, H. O. House, W.A. Benjamin, California, (1972).
6. Organometallics, Vol. 1 & 2, M. Bochmann, Oxford Chemistry primers, Oxford University Press, (1994).

7. Advanced Organic Chemistry, 4th Edition,J. March, John Wiley, (2008).
8. Organo-transition metal chemistry, S. G. Davies, Pergamon Press, Oxford, (1982).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ310	CO1	1		1	1	1		1	1			1	1	1
	CO2	2	1	2		3	1	2	2			2	2	2
	CO3	2	1	2		3	1	2	2			2	2	2
	CO4	2	1	1		2	1	1	2			2	1	1

SEMESTER-III: ORGANIC CHEMISTRY SOFT CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS302	GREEN CHEMISTRY-III.5	DSEC/SC	2	0	0	2	2

Course objectives:

This course aims to provide the student to gain

i. Knowledge of green chemistry through various concepts
ii. Application of instrumental techniques for the synthesis of green materials or compounds
iii. Outline on the synthesis of green materials through various chemical routes
iv. Design the concept and discipline of green chemistry and place its growth and expansion in a historical context from.

Course outcome:

By the completion of course student will be able to

CO1. Employ alternate methods for material synthesis towards better sustainability.
CO2. Design reaction schemes for developing new green products.
CO3. Identify environmental friendly chemicals and techniques for materials synthesis.
CO4. Analyse materials for their applications based on their chemical properties.

Course Content:

UNIT-I

Introduction to green chemistry: Green chemistry: Relevance and goals, Anasta's, 12 principles of green chemistry -tools of Green chemistry:- Alternative starting materials, reagents, catalysts, solvents and processes with suitable examples

Use of ultrasound and Microwaves in Organic Synthesis

Use of ultrasound: Introduction, instrumentation, the phenomenon of cavitation. Sonochemical esterification, substitution, addition, alkylation, oxidation, reduction and coupling reactions.

Use of Microwaves: Introduction, concept, reaction vessel/medium, specific effects, atom efficiency (% atom utilization), advantages and limitations. N-alkylation and alkylation of active methylene compounds, condensation of active methylene compounds with aldehydes and amines. Diels-Alder reaction. Deprotection of esters and silyl ethers. **[8 hrs]**

UNIT-II

Ionic-liquids: Introduction, structure, synthesis and applications of some important ionic liquids in organic synthesis Polymer supported reagents in organic synthesis Introduction- properties of polymer support, advantages of polymer supported reagents and choice of polymers.

Applications: Substrate covalently bound to the support: Synthesis of oligosachcharides, Dieckmann cyclisation. Preparation of polymer bound aldehyde and application in aldol and Wittig reactions. Synthesis of polystyryl boronic acid and use in diol protection reaction. Reagent linked to a polymeric material: Preparation of sulfonazide polymer and application in diazotransfer reaction. Synthesis of polymer bound per acid and its applications. Polymer supported catalytic reactions: Preparation of polymer supported AlCl3 and application in etherification and acetal formation reactions. **[7 hrs]**

UNIT-III

Phase transfer catalysis and Crown ethers

Phase transfer catalysis: Introduction, definition, mechanism of phase transfer catalysis. Types of phase transfer catalysts and reactions and their Advantages.

Preparation of catalysts and their application in substitution, elimination, addition, alkylation, oxidation and reduction reactions.

Crown ethers: Introduction, nomenclature, features, nature of donor site. General synthesis of Crown ethers.

Synthetic applications: Alkylation, generation of carbenes, aromatic substitution and displacement reactions. Generation and application of superoxide anions. Cation deactivation reactions. **[8 hrs]**

UNIT-IV

Supported catalyst and Bio-catalyst for Green chemistry

Introduction-the concept of atom ecomnomy-supported metal catalsts-mesoporous silicas-the use of biocatalyst for green chemistry-modified biocatalyst-Fermentations and Biotransformations-fine chemicals bymicrobial fermentations- vitamins and amino acids -Baker's yeast mediated bio transformation-biocatalyst mediated Bayer-Villiger reactions -Microbial polyester synthesis.

Multi-component Reactions: Studies on the mechanistic aspects and use of the following reactions in organic synthesis: Passerini-Ugi; Hantsch; Biginelli; Doebner-Miller; Ritter; Jacobson; Betti; Robinson-Schopf; Barbier; Baylis-Hilmann; Ivanov and Suzuki coupling reaction. **[7 hrs]**

References:

1. Green Chemistry -Environmentally benign recations- V.K. Ahluwalia. Ane Books India (Publisher) (2006).
2. Green Chemistry-Designing Chemistry for the Environment- 2nd Edition, Edited by Paul T. Anastas & Tracy C. Willamson, (1998).
2. Green Chemistry-Frontiers in Benign Chemical synthesis and Processes- Edited by Paul T. Anastas & Tracy C. Willamson. Oxford Press (1998).
3. Organic Chemistry, R. E. Ireland Prentice-Hall India, New Delhi, (1975).
4. Some modern methods of Organic Synthesis, 2nd Edition, W. Caruthers, Cambridge Uni. Press London, (1998).
5. A textbook of organic chemistry, V. K. Ahluwalia and M. Goyal, Narosa Publishing House, New Delhi, (2000).
6. Organic synthesis: Special techniques, V. K. Ahluwalia and R. Aggarwal, Narosa, New Delhi, (2003).
7. Green Chemistry- environment friendly alternatives, R. Sanghi, M. M. Srivastava, Narosa, New Delhi, (2003).
8. Green Chemistry-an introduction text, Royal Society of Chemistry, UK, (2002).
9. Organic chemistry Vol. 2, 6th Edition, I. L. Finar, Longman, (1992).
10. Crownethers and cryptands, G.W.Gokel, Monograph, The Royal Society of Chemistry, (1991).
11. Macrocyclic Polyether Chemistry, G. W. Gokel, S. M. Korzeniowski, Vol 1 to 3, Wiley, NY, (1978, 1981, 1987).
12. Phase Transfer Catalysis in Organic Synthesis, W. B. Weber, G. W. Gokel, Springer, Berlin, (1977).
13. Phase Transfer Catalysis, 2nd Edition, E. V. Dehmlov, S. S. Dehmlov, Verlagchemie, Wienheim, (1983).
14. Polymers as aids in organic synthesis, N. K. Mathur, C. K. Narang, R. E. Williams, Academic Press, NY, (1980).

Mapping of Course Outcomes with programme Outcomes (sample)

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS302	CO1	2	2	1	2	1	2		1			2	2	1
	CO2	3	1	2	2	2	3		2			2	1	2
	CO3	2	3	2	1	2	2		2			1	2	3
	CO4	3	2	2	1	2	1		2			2	2	3

SEMESTER-III: PHYSICAL CHEMISTRYHARD CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ313	PHOTO PHYSICAL PROCESSES AND APPLICATIONS-III	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Principles and laws of photochemistry,
ii. Measurement of fluorescence and phosphorescence and lifetimes
iii. Fluorescence based sensors.

Course Outcomes:

By the completion of course student will be able to

CO1. Acquire knowledge on laws of photo chemistry, types of electronic transitions and their kinetics.
CO2. Study of various methods to understand fluorescence and phosphorescence processes.
CO3. Explain Fluorescence based sensors with relevant examples.
CO4. Describe principle of photovoltaics, various energy conversion devices and their applications.

Course Content:

UNIT – I

Principles and concepts: overview of: Laws of photochemistry, Beer-Lambert law, electronic energy levels, atomic and molecular term symbols, singlet-triplet state, intensity and strength of electronic transition, selection rules for electronic transition, singlet, triplet states, Jablonski diagram and photophysical processes, Franck-Condon principle, Quantum yield, Quenching. Different types of electronic transitions, Excited state lifetime, steady state and time resolved emission, factors affecting excited state energy: solvent effect, TICT. **[15 hrs]**

UNIT-II

Excited state kinetics, quantum yield expressions, excimer and exciplex, kinetics of luminescence quenching: static and dynamic, Stern-Volmer analysis, deviation from Stern-Volmer kinetics. Photoinduced electron transfer rates, free energy dependence of electron transfer on rate, Photoinduced energy transfer, FRET, rate and efficiency calculation of FRET. **[15 hrs]**

UNIT – III

Methods: Measurement of fluorescence and phosphorescence and lifetimes. Quantum yield, Introduction to time-resolved techniques for absorption and emission measurements, detection and kinetics of reactive intermediates. Examples of low temperature matrix isolation of reactive intermediates. **[15 hrs]**

UNIT – IV

Applications: Fluorescence based sensors – examples of molecular and supramolecular systems. Conversion of solar energy to chemical and other forms of energies, Principles of photovoltaics, Semiconductors, crystalline solid in Photoactive materials, solar photovoltaic cell, basic principle and design of the cell. Organic photovoltaics, Dye sensitized solar cells, Emission devices, Light emitting devices, LED, organic LED. **[15 hrs]**

References:

1. Physical Chemistry, 4th Edition, P.W. Atkins, ELBS, Oxford University Press (1990).
2. Elements of Physical Chemistry, S. Glasstone, MacMillan.
3. Modern Spectroscopy, 4th Edition, J. M. Hollas, John Wiley & Sons, (2004).
4. Modern Optical Spectroscopy, Student Edition, William W. Parson, Springer, (2009).
5. Fundamentals of Photochemistry, K. K. Rohatgi-Mukhejee, Wiley Eastern Ltd, (1992).
6. Principles of Fluorescence Spectroscopy, 3rd Edition, J. R. Lakowicz, Springer, (2006).
7. Laser Spectroscopy- Basic concepts and instrumentation, 3rd Edition, W. Demtroder, Springer,(2004).
8. Fundamentals of Photoinduced Electron Transfer, G. J. Kavarnos, VCH publishers Inc., New York, (1993).
9. Modern Molecular Photochemistry of Organic Molecules, N. J. Turro, V. Ramamurthy, J. C. Scaiano, University Science, Books, CA, (2010).
10. Photochemical Synthesis, I. Ninomiya, T. Naito, Academic Press, New York, (1989).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ313	CO1	2	2	1	1	1	2	2	1	1	2	2	2	1
	CO2	1	2	2	2	2	2	2	2	1	2	3	2	2
	CO3	2	1	2	3	2	1	3	2	2	2	2	1	1
	CO4	2	2	3	2	2	2	2	2	1	3	3	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Wk
M21SMZ314	FUNDAMENTALS OF ELECTROCHEMISTRY AND APPLICATIONS-III	HC	4	0	0	4	4

Course of Objective

This course aims to provide the student to

i. Explain the fundamental concept, principles and laws of electrochemistry,
ii. Discuss related to the types of electrodes and study of electrode reactions pathway.
iii. Explain the concept of spectro-electrochemical and spectroscopic techniques.
iv. Construction of electrode materials for various applications.

Course of Outcome

By the completion of course student will be able to:

CO1. Illustrate the electrochemical reactionand mechanism.

CO2. Development of electrode materials in various applications.

CO3. Apply the spectro-electrochemical and spectroscopic in better understanding structural feature and prospective of electrode materials.

CO4. Design the new electrode materials for various applications in the field of electrochemical sensors and electrochemical energy devices.

Course Content:

UNIT – I

Electrochemical cells, Electrical double layer theories, Electrolyte conduction process, different types of electrochemical cells, Mass transport, Linear diffusion, Fick's laws and diffusion coefficient, The charged interface, Potential step and potential sweep experiments, Reactions controlled by rate of electron transfer and activated complex theory, Role of electron tunneling. **[15 hrs]**

UNIT – II

Electrode Types and Study of Electrode Reactions: Carbon electrodes, Semiconductor film electrodes, Microelectrodes, Ultra-micro electrodes, Ion-selective electrodes, Porous electrodes and non uniform reaction rates, Hydrodynamic/Rotating disk electrodes, Semiconductor electrodes and electrical capacitance.

Cyclic voltammetry in reversible, quasi-reversible and irreversible systems, Study of reaction mechanisms, Surface modification in charge transfer and interfacial activity Electron transfer in DNA and biosystems, Potentiometry, coulometry, pulse techniques. **[15 hrs]**

UNIT-III

Spectro-Electrochemical and Spectroscopic Techniques: Impedance Spectroscopy, Scanning Electrochemical Microscopy, Electrochemical AFM and STM, Electrochemical Quartz Crystal Microbalance, Photoelectochemistry.

Electrode Materials and Sensors: Electroactive Fullerenes, Carbon Nanotubes, Biomolecules, Controlled Potential Techniques, Electrochemical synthesis of nanomaterials, nanowires and conducting polymers, Functional nanoparticles as catalysts and sensors, MOSFETS and ISFETS, Solid state molecular devices.

[15 hrs]

UNIT-IV

Electrochemical Energy Systems: Photo-electrochemistry, Monitoring photolytic intermediates, Electroluminescence and devices and sensors, Electro - chemiluminescence, Digital simulation of electrochemical problems, Sample BASIC programs.

Fuel cells: Electrode materials, Diagnostic tools in fuel cell research, Determination of injection efficiency and electron diffusion length under steady state condition, Small-amplitude time-resolved methods, Organic solar cells, DSSC, battery electrochemistry. **[15 hrs]**

References:

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

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3

M21S MZ310	CO1	2	2	3	3	3	3	1	1	1	2	3	3	3
	CO2	2	3	1	2	2	2	1	2	1	2	3	2	2
	CO3	3	3	1	2	3	1	1	2	1	2	2	2	2
	CO4	2	2	3	3	3	3	1	1	1	2	3	3	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ315	ADVANCED PHYSICAL CHEMISTRY-III	HC	4	0	0	4	4

Course objectives:

This course on physical chemistry provides students to enlighten the knowledge on topics like

i. This course intends to make the students to understand topics like quantum chemistry and its application is in molecular architecture.
ii. Bring awareness about the differences in Statistical Thermodynamics and non equilibrium thermodynamics and molecular motions.
iii. To develop the ideas pertaining to molecular interactions in quantum level.
iv. To build and utilize knowledge of macro molecules in the construction of new drug entities.

Course outcomes:

After completion of the course student will,

CO1. Analyze the quantum mechanical aspects in the molecular dynamics.

CO2. Acquire knowledge on Schrodinger equation, particle in box, Characteristics of many electron systems.

CO3. Understand the statistical thermodynamics, non equilibrium thermodynamics, Molecular forces, Electrical properties of molecules.

CO4. Construct ideas pertaining to the statistical thermodynamics and macro molecular interactions.

Course Content:

UNIT – I

Quantum Chemistry II: Solutions of Schrondinger equation for: free particle in 1D, finite and infinite potential wells, Particle in 3D box, Zero point energy significance, 1D Harmonic oscillator, selection rules in vibrational transitions, Many body problem, approximations, independent particle model, Perturbation method. Application to particle in 1D box of increasing potential, Helium atom, Self consistent field method, Hartee Equation and Hartee-Fock Equations. Pauli"s exclusion principle, Symmetry and antisymmetry wave functions.Spin orbit coupling, Term symbols and spectral lines.

Characteristics of many electron systems, Born-Oppenheimer approximation, Valence bond and Molecular orbital theory, Electron density distribution and stability of H_2^+ ion. **[15 hrs]**

UNIT – II

Statistical Thermodynamics and non equilibirium thermodynamics: Transitional, rotational, vibrational and electronic partition functions of diatomic molecules, Calculation of thermodynamic functions including chemical potential, equlibrium constant, salient features of Fermi-Dirac and Bose-Einstein statics.

Non equilibrium thermodynamics: Thermodynamic fluctuation around equilibrium, Entropy production, energy flux, thermodynamic flux, thermodynamic force, phenomenological laws and Onsagar reciprocity relations, Applications. **[15 hrs]**

UNIT – III

Molecular Interactions: Molecular forces, Electrical properties of molecules, electric dipole moments, Molar Polarization, Mosotti-Clausius and Debye-Langevin equation – their derivation, uses and limitations, Onsagar equation, Ferro-electricity, Intermolecular forces, London dispersion force, Lennard-Jones potential, Nature of binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, H-bonding, cation-p, anion-p, p-p, and van der Waals interactions., Crystal engineering: role of H-bonding and other weak interactions. Dielectric effects in absorption and emission spectra in solution, Lippert equation.Molecular interaction in liquids. **[15 hrs]**

UNIT – IV

Macromolecules: Introduction, Classification, Nomenclature, Different structures, Viscosity, Molecular weight determination, Flory-Huggins theory, Amorphous and semicrystalline states, glass transition and related theories, melt transition, viscoelasticity, Maxwell-Voight models, Rubber elasticity – thermodynamic theories. Macromolecule motion. Kinetics and mechanism of addition and condensation polymerisation, Biological macromolecules, Properties of macromolecules. **[15 hrs]**

References:

1. Quantum Chemistry, 2nd Edition, A.K. Chandra. Tata McGraw Hill Publishing Co. Ltd., (1983).
2. Quantum Chemistry, Eyring, Walter and Kimball. John Wiley and Sons, Inc., New York.
3. Quantum Chemistry, I.N. Levine. Pearson Education, New Delhi, (2000).
4. Theoretical Chemistry, S. Glasstone. East West Press, New Delhi, (1973).
2. Quantum Chemistry, R.K. Prasad, New Age International Publishers, (1996).
3. Statistical Thermodynamics, I.M. Klotz.
4. Introduction to Statistical Thermodynamics, M. Dole, Prantice Hall, (1962).
5. Statistical Themodynamics, B.C. Meclelland, Chapman and Hall, London (1973).
6. Physical Chemistry, P.W. Atkins, ELBS, 4thEdition, Oxford University Press (1990)
7. Elements of Physical Chemistry, S. Glasstone, MacMillan.

8. Thermodynamic Properties of Nonelectrolyte Solutions, Acree W.E., (Academic Press, (1984).
9. Chemical Thermodynamics: Advanced Applications, 1st Edition, J. Bevan Ott, Juliana Boerio-Goates, (Academic Press, (2000).
10. The Molecular Theory of Solutions, Prigogine, North Holland Publishing Co. Amsterdam (1957).
11. Molecular Theory of Solutions, Arieh Ben-Naim, Oxford University Press, USA, (2006).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ315	CO1	3	2	1	3	2	3	1	1	1	1	3	2	2
	CO2	3	2	1	1	2	2	1	1	1	1	3	2	2
	CO3	3	2	1	2	2	1	2	1	1	1	3	2	2
	CO4	3	2	3	1	1	1	1	2	1	1	3	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ316	POLYMER SCIENCE AND TECHNOLOGY-III	SC	4	0	0	4	4

Course Objectives:

i. Broad knowledge on polymer science and technology intends to make the students to understand basic concepts of polymers.
ii. Develop knowledge on thermodynamics of polymer solutions.
iii. Enhanced knowledge on classification, structure-property relation of polymers and different applications of polymers.
iv. Expert in mechanism of polymerization, instrumentation method of polymer characterization.

Course Outcomes:

After completion, of course student will be able to:

CO1. Demonstrate the knowledge of the basic concept of polymer, analysis of molecular weight of polymer.

CO2. Explore physical factors of polymers, analysis of glass transition temperature of polymer, Thermodynamic equation of polymer.

CO3. Create broad knowledge on polymer classification, mechanism of polymerization, instrumentation method of polymer characterization.

CO4. Acquire broad knowledge of polymers for medical, environmental, catalysis and device applications

Course Content:

UNIT – I

Basic concepts - classification, nomenclature, molecular weights, molecular weight distribution, glass transition, degree of crystallinity, morphology, and viscosity-molecular weight, mechanical property - molecular weight relationships. Molecular weights and Methods of determination, molecular weight distribution, size and shape of macromolecules. Intrinsic viscosity, Mark-Houwink relationship.

Chain structure and configuration, conformation, size of an ideal chain (freely jointed chain and other models), Real chains, Flory theory. **[15 hrs]**

UNIT – II

Thermodynamics of polymer solutions; Molecular motion (self-diffusion, hydrodynamic radius, Rouse Model, Zimm Model, entangled polymer dynamics and de Gennes reptation model).

Glass transition temperature – elementary theories and methods of determination. Variation of glass transition with structure.

Rubber elasticity - concepts, thermodynamic equation of state. Elementary theories of viscoelasticity (Maxwell, Voight). **[15 hrs]**

UNIT – III

Classification of polymers, Structure- property relationship, Mechanisms and Methods of Polymerization - Step (condensation) polymerization - Description - Reactivity Functional Groups - Kinetic and thermodynamic considerations - Molecular weight distribution. Chain polymerization, controlled radical polymerizations (INIFERTER, ATRP, RAFT, SET). Living Polymerizations. Ziegler-Natta and metathesis polymerizations. Kinetics and mechanism of addition and condensation polymerization, Moulding and fabrication of polymer. Introduction to Instrumental methods for characterization of polymers. **[15 hrs]**

UNIT – IV

Applications of Polymers: Electrically conductive polymers, Charge transport mechanism, Photoactive polymers, OLED, polymers energy conversion devices, corrsion prevetion, Thermal resistant polymers, catalysis, medical prothesis, Metallopolymers, metalloorganic frameworks, applications, biodegradable polymers, degradation pathways, environmental effects. **[7 hrs]**

References:

1. Polymer Structure, Properties and application, R.D. Deanin, American Chemical Society, (1974).
2. Relating Materials, Properties to Structure, Handbook and Software for Polymer calcilations and Materials Properties, D. J. David and Ashok Mishra, Technical Publishing Componey, Inc, (1999).
3. Properties of Polymer; Correlations with Chemical Structurees and their numerical Estimation and Predication from Additive Group Contribution van Krevelen, Elsevier Publication Company, (1990).
4. Relating Materials Properties to structure, D. J. David, Technical Publishing Company Inc, (1999).
5. Polymer Chemistry, C. E. Carrshar, Marcel Dakker Inc, (2003).
6. Physical chemistry of Polymers, A. Tager, Mir Publishers, (1978).
7. Polymer Association Structures M. A. EL-Nokally, American Chemical Society, (1989).
8. Polymer Solutions- Introduction to Physical Properties, Teraoka, Iwao, John Wiley and Sons. Inc, (2002).
9. Polymer Chemistry- An Introduction, M. P. Stevens, Oxford University Press, (1990).

10. Text book of Polymer Science, Billmeyer, John Wiley ans Sons,(1984).
11. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons Inc (1965).
12. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons Inc (1988).
13. Polymer Chemistry, Malcolm P. Stevens, Oxford University Press, Inc, (1990).
14. Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Inter Science Publication, (1977).

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ Cos**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21S MZ316	CO1	2	1	1	2	1	1	1	2	1	2	2	2	1
	CO2	2	2	2	2	1	2	1	2	1	2	2	2	2
	CO3	2	1	1	1	1	2	1	1	1	1	2	2	2
	CO4	2	1	2	1	1	1	1	1	1	2	2	2	1

SEMESTER-III: PHYSICAL CHEMISTRY SOFT CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS303	ENERGY AND ENERGY CONVERSION SYSTEMS	SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Fundamental importance of energy and energy conservation required to have sustainable life.
ii. The present situation of the availability non-renewable energy resources and reason to shift over to renewable energy sources.
iii. The different renewable energy sources and how to make use of them for our day to day life.
iv. Methods involved in converting and storing of the renewable energy sources for the continuity supply of energy.

Course outcomes:

By the completion of course student will be able to

CO1. Explore the Renewable and non-renewable energies, their advantages and disadvantages, Environmental effects.

CO2. Analyse the status of the renewable and non-renewable sources in the world and discuss the importance of renewable sources

CO3. Acquire the knowledge of renewable sources and list out the different renewable sources to convert, store, and usage in daily life.

CO4. Evaluate the efficiencies of solar cells, electrochemical energy conversion (HER and OER), storage (batteries, and supercapacitors) and fuel cells with their examples.

Course Content:

UNIT – I

Energy systems - Available energy options, Renewable and non renewable, their advantages and disadvantages. Environmental effects, comparative evaluation of energy options and energy needs.

Fossil fuels: petroleum, natural gas and coal - Origin, processing and production of value added products - available current conversion technologies.

Nuclear Energy: Principles of Fission - Fission reactors, U enrichment and processing of spent fuels. Nuclear reactor kinetics and control - nuclear fusion - magnetic and other confinement - evaluation of the option of nuclear energy. **[8 hrs]**

UNIT – II

Electrochemical power sources - theoretical background on the basis of thermodynamic and kinetic considerations.

Primary cells - various types, especially magnesium and aluminum based cells - magnesium reserve batteries.

Secondary cells: classification based on electrolyte type, temperature of operation on the basis of electrodes - chemistry of the main secondary batteries - Batteries for electric vehicles - present status.

[8 hrs]

UNIT – III

Fuel cells - classification - chemistry of fuel cells - detailed description of hydrogen/oxygen fuel cells - methanol - molten carbonate, solid oxide fuel cells solid polymer electrolyte and biochemical fuel cells.

Hydrogen as a fuel - production (thermal, electrolysis, photolysis and photoelectrochemical) storage and applications of hydrogen storage.

Other methods of energy conversion: processes especially in the form of storage as chemical energy.

[7 hrs]

UNIT – IV

Semiconducting materials, Solar energy conversion devices, principle, Photoconversion processes - photovoltaic cells - photoelectrochemical cells - semiconductor electrolyte junctions photocatalytic modes for fuel conversion process - photobiochemical options. **[7 hrs]**

References:

1. Modern Batteries, C. A. Vincent Edward Arnold, (1984).
2. Chemical and Electrochemical energy systems, R. Narayanan, B. Viswanathan, Orient Longmans, (1997).
3. Basic Nuclear Engineering, K. Sriram, Wiley Eastern, (1990).
4. Fuel cell Hand Book, A. S. J. Appleby, F. K. Foulkes, Von Nostrand Reinhold, (1989).
5. Hand book of batteries and Fuel cells, D. Linden, McGraw Hill Book Company, (1984).
6. Solar Hydrogen energy systems, T. Ohta, Peragamon Press, (1979).
7. Energy Resources through photochemistry and catalysis, M. Gratzel, Academic Press, (1983).
8. Energy Technology, Sources, Systems and Frontiers conversions, T. Ohta, Pergamon, (1994).
9. The chemistry and technology of petroleum, J. G. Speight, Marcel Dekker Inc. (1980).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS303	CO1	2	1	2	1	1	2	1	1	2	1	2	1	2
	CO2	1	1	1	2	1	2	1	1	1		1	1	1
	CO3	3	1	2	1	2	1	1	1	1	1	1	1	1
	CO4	2	2	2	2	2	2	1	1	1	1	2	3	2

SEMESTER-III: ANALYTICAL CHEMISTRY HARD CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ319	ADVANCED ANALYTICAL CHEMISTRY-III.1	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. To understand the separation and extraction of compounds by different methods.
ii. Exposure to the various analytical techniques for the detection of elements in the solution.
iii. Highlights and study of instrumental techniques such as Atomic and atomic Spectroscopy.
iv. Development of sensors, optical, biosensors and their type's correlation with basic instrument.

Course Outcomes:

By the completion of course student will be able to

CO1. Identification of the elements and their properties by using instrumental methods.
CO2. Explain the various extraction methods involved during the separation of the compounds.
CO3. Elaborate the principle, instrumentation and applications of various analytical and spectroscopic techniques.
CO4. Design the detectable concentration of a given specific analytes.

Course Content:

UNIT-I

Classical approach for aqueous extraction: Introduction, Liquid-Liquid extraction (LLE) (Theory of LLE, selection of solvents, solvent extraction, problems with LLE process), purge and trap for volatile organics in aqueous samples.

Solid Phase extraction (SPE): Introduction, Types of SPE media, SPE formats and apparatus, method for SPE operation, solvent selection, factors affecting SPE, selected methods of analysis for SPE, Automation and On-Line SPE. Microwave assisted extraction: Introduction, instrumentation, Applications.

Solid phase micro-extraction: Introduction, theoretical considerations, experimental, Methods of analysis: SPME-GC, SPME-HPLC-MS.**[15 hrs]**

UNIT-II

Atomic Spectroscopy: Theory, sources, burners, atomic emission spectra, atomic absorption spectra, effect of temperature on emission, absorption and fluorescence, electro thermal atomizers, Instrumentation for FES, radiation sources atomic absorption methods, instrumentation for AAS, spectral interferences, standard addition and internal standard method of analysis, comparison of atomic absorption and emission methods, inductively coupled plasma and direct current plasma emission spectroscopy, Cold vapor technique, Applications of AAS, AES and ICPAES, analysis of micronutrients like Mo, B, Cu, Zn essential towards the healthy growth of crops, fruits, determination of these micronutrients from soils, plants and fruits. **[15 hrs]**

UNIT-III

Atomic Mass Spectroscopy: Features of atomic mass spectroscopy, Atomic weight in mass spectroscopy, mass to charge ratio, Types of atomic mass spectroscopy, mass spectrometers, transducer for mass spectroscopy, qudrapole mass analyzer, time of flight mass analyzer, inductively coupled mass spectroscopy (ICPMS), Isotopic effect, HRMS to identify the isotopes, Instrumentation for ICPMS, Atomic mass spectra and interferences, Applications of ICPMS special reference to the inorganic complexes analysis

Atomic Fluorescence, Resonant Ionization and laser based-Enhanced Ionization:

Atomic Fluorescence Spectroscopy (AFS): Atomic fluorescence, apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasmas, Wavelength selection for AFS, Detectors for AFS, Theory of AFS, Analysis with AFS, Interference With AFS. Resonanant Ionization Spectroscopy, Laser-enhanced ionization spectroscopy. **[15 hrs]**

UNIT-IV

Chemical Sensors: Introduction, definitions, Classification of chemical sensors, descriptions of chemical sensors (electrochemical sensors, potentiometric sensors, voltametric chemical sensors, sensors based on conducting properties), Optical sensors (light guides, the evanescent wave, design of fiber optic sensor, indicator mediated sensor), Calorimetric sensors (catalytic gas sensor, thermal conductivity sensor), mass sensor (piezoelectric quartz crystal resonator, surface acostic wave sensor).

Biosensors in analysis: Introduction, producing biological surface, Achievement of biotransduction (amperometric, potentiometric, optical).

Applications: Determination of glucose in blood, determination of copper (I) in water using anodic stripping voltammetry. **[15 hrs]**

Reference Books:

1. Instrumental methods of chemical analysis, H. Willard, L.Merrit, J.A. Dean and F.A. settle. Sixth Edition CBS (1986).
3. Principles of Instrumental Analysis, 6th Edition, Skoog, Holler, Nieman.
4. Extraction technique in analytical science, John R. Dean, Wiley (2009).
5. Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Ed Vogel, 3, ELBS, (1964).
6. Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman, Harcourt College Pub.

Mapping of Course Outcomes with Program Outcomes

Course Code	**POS/ Cos**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21S MZ319	CO1	3	2		2	3		1	1	1	2	3	3	3
	CO2	2	2	1	3	3	2	1	1	1	2	3	2	3
	CO3	3	3		3	3	1	2	1	1	2	4	3	2
	CO4	4	3	1	3	3	1	2	1	1	2	4	4	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ320	ADVANCED MATERIALS, ANALYSIS AND ELECTRON SPECTROSCOPY-III.2	HC	4	0	0	4	4

Course Objective:

This course aims to provide the student to

i. Explain emerging trends in nanotechnology and scope of other materials like zeolites.
ii. Discuss the various techniques involved in synthesis of ceramics and nanomaterials.
iii. Make use of different spectroscopic techniques for chemical analysis.
iv. Analyse the applications of nanomaterials in various fields like agriculture, health, electronics, medical, food safety etc.

Course Outcome:

By the completion of course student will be able to

CO1. Discuss emerging trends in nanotechnology and scope of other materials like zeolites
CO2. Explain the various techniques involved in synthesis of ceramics and nanomaterials
CO3. Demonstrate the knowledge spectroscopic techniques for chemical analysis
CO4. Characterize the materials by different analytical techniques for various fields like agriculture, health, electronics, medical, food safety etc.

Course Content:

UNIT-I

Scope of materials science: Types of materials based on structure (i) layered materials (clays, MoS2, LDH) (ii) Porous materials: Microporous (zeolites), Mesoporous materials (MCM-41) (iii) Metal Organic Frameworks and dendrimers. (Structure and applications in each case need to be discussed) Introduction and definition of nanoparticles and nanomaterials, emergence of nanotechnology, Challenges of nanotechnology. Nanotechnology in relation to other branches of science. Structure of solids: crystalline and non-crystalline. Types of common materials and advanced materials inorganic, organic, biological. Types of nanomaterials depending upon their properties: electronic, semiconductors, superconductors, superionic, magnetic, optic, opto-electronic, spintronics, ceramics. **[15 hrs]**

UNIT-II

Preparation techniques: Principles of solid state synthesis-ceramic methods, solid solution and compound precursors, sol- gel, spray, pyrolysis, and combustion, hydrothermal, electrosynthesis. Preparation of

nanoscale materials: Precipitation, mechanical milling, colloidal routes, self-assembly, chemical vapour deposition, sputtering, evaporation.

Overview of inorganic functional materials, their properties and applications. Crystal structure and amorphous materials. Defects and non-stoichiometric solid solutions. Band theory and electronic conductivity. Synthesis and processing of inorganic materials. Properties of inorganic materials: superconductivity, magnetic, dielectric and optical properties. **[15 hrs]**

UNIT-III

Electron spectroscopy: Introduction, principle of electron spectroscopy for chemical analysis(ESCA), ESCA satellite peaks, spectral splitting, ESCA chemical shifts, Apparatus used for ESCA, X-ray source, samples, Analyzers, Detectors, Chemical analysis using ESCA, Applications, Auger electron microscopy, Ultraviolet photoelectron spectroscopy**.**

X- ray Methods of Analysis: Principle, Theory- X-ray spectral lines, X-ray tube, X-ray emission, Absorptive apparatus: Sources, Collimation, sample handling, wavelength dispersive devices, Energy dispersive devices, detectors, readout device, Chemical analysis using X-ray absorption, X-ray Fluorescence- instrumentation and chemical analysis, X-ray Diffraction, Chemical analysis with X-ray diffraction, numerical problems. Single crystalline and polycrystalline XRD analysis

[15 hrs]

UNIT-IV

Materials Characterization techniques: Principle, technique and specific applications of Electron microscopy (TEM and SEM), Focussed Ion Beam Techniques, Atomic Force Microscopy, Scanning tunneling microscopy (STM),BET surface area, porosity, solid state NMR (introduction).

Basic principle, instrumentation and application of Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy (TDS).

[15 hrs]

Reference:

1. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, New York, (1993).
2. Nanostructures and nanomaterials, G. Cao, Imperial College Press, University of Washington, USA, (2004).
3. Nanotechnology Fundamentals and applications, M. Karkare, I. K. international publishing house pvt. Ltd., Bangalore, (2008).
4. Springer Handbook of Nanotechnology, 3rd Edition, B. Bhusan, Springer-Verlag, (2009).
5. Principles of Fluorescence Spectroscopy, 3rdEdition, J. R. Lakowicz, Springer, (2006).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ320	CO1	3	3	1		2	1	1	2		2	2	4	3
	CO2	4	3	3	2	3	3	1	2	1	2	3	4	2
	CO3	2	1	3	3	3	2	1	1	1	2	3	4	3
	CO4	1	3	3	2	3	3	1		1	2	2	4	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ321	ELECTROCHEMISTRY AND ELECTROANALYTICAL TECHNIQUES –III.3	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to

i. Knowledge on Electrode/electrolyte interfaces, kinetics of electrochemical processes at metal/solution and SC/solution interface.
ii. Expose into the different coulometric and voltametric techniques to enhance the analysis knowledge of elelctrochemical reactions
iii. Further, exploring hydrodynamic processes and appreciate the importance of impedance spectroscopy in understanding and analysing the electrochemical process.
iv. Finally, expose them to different in-situ-spectroelectrochemical methods.

Course Outcomes:

By the completion of course student will be able to

CO1. Acquire the knowledge Mass transport, Linear diffusion, Fick's laws and diffusion coefficient, the charged interface, Potential step and potential sweep experiments.

CO2. Analyze the compounds by using the analytical techniques such as Chronocoulometry and potentiometery methods.

CO3. Analyze the hydrodynamic, voltametric techniques and impedance spectroscopy and extract the electrochemical reaction information.

CO4. Assessment of the electrochemical process using the different in-situ-spectro-electrochemical methods.

Course Content:

UNIT-I

Electrified interface and electrodics: Formation of electrified interfaces. Electrical double layer and different models. Introduction to three electrode electrochemical devices (arrangement of electrodes to get minimum resistance),iR compensation, electro transfer under an interfacial electric field, Butler-Volmer equation and its modifications and applications with electrochemical water splitting (HER), theory of the symmetry factor (beta). Thermodynamic treatment of the equilibrium state for charge transfer at the metal/solution interface. Mass transport and electrode processes: Faradaic and non-Faradaic processes,

Nernst-Planck equation, Nernstian and non-Nernstian behaviour, Fick's first and second law and their application in mass transport, kinetic and transport-controlled processes.

Electrode kinetics for semiconductor/solution interface: n-p junction, current-potential relation at the SC/electrolyte interface, effects of surface states, use of SC in thermal reactions, photo activity of SC electrodes. **[15 hrs]**

UNIT-II

Step techniques: Basic principles, potential excitation signals and response signals of chronoamperometry, chronocoulometry and chronopotentiometry (single and double potential steps). Use of Cottrell and Sand equations and applications. Evaluation of heterogeneous kinetic parameters and adsorption of species on the electrode surface.

Pulse and stripping techniques: Pulse techniques: fast, normal & differential pulse and square wave voltammetry (principle, comparative potential excitation signals and response signals), pulse width, diminution factor. Application and relative advantages of different pulse techniques. Some special pulse techniques: reverse pulse, differential normal pulse and double differential pulse voltammetry. Stripping techniques: different types of stripping techniques (anodic, cathodic, potentiometric, adsorptive and abrasive) and their comparative preconcentration and determination step, use of pre-concentration techniques at trace and ultra-trace level analysis, use of pre-concentration step for mercury film electrode in metal-ligand complex study. **[15Hrs]**

UNIT-III

Hydrodynamic voltammetry: Useful parameters (comparison of diffusion layer thickness: dynamic and static conditions, relation of hydrodynamic condition with Reynolds, Schmidt, Peclet and Sherwood numbers). Practical considerations: potentiostat and electrodes in hydrodynamic system, RDE and RRDE. Reversible and irreversible kinetics in hydrodynamic condition, use of Levich, Koutecky-Levich equations and Tafel plot and applications. Evaluation of kinetic control and diffusion control processes. Applications of hydrodynamic voltammetry.

Impedance spectroscopic techniques: Impedance, detection and measurements of impedance, equivalent circuit of an electrochemical cell, the Faradaic impedance and the total impedance of a simple electrode process, impedance plots for complex plane. Admittance and its use. Hydrodynamic electrodes and impedance. Transforms and impedance, application of impedance for characterization of corrosion and capacitors. **[15 Hrs]**

UNIT-IV

Spectro-electrochemistry and scanning electrochemical microscopy: Principles, electrochemical set-up and applications, electro-chemiluminescence, optical probing of electrode-solution interfaces. Approach curves for scanning electrochemical microscopy, imaging surface topography, applications in homogeneous

reaction kinetics and others. Electrochemical quartz crystal microbalance, Photo-electrochemical measurements, Spectroelectrochemistry: Electrochemical STM, Electrochemical AFM, Spectroelectrochemistry (insitu-UV-vis, IR, Raman), Sonoelectrochemistry.

[15 hrs]

References:

1. Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Allen J. Bard and Larry R. Faulkner, John Wiley & Sons, (2001).
2. Electroanalytical Chemistry, Vol.13, Allen J. Bard (Ed), Plenum Press, (1983).
3. Analytical Electrochemistry, 3rd Edition, Joseph Wang, John Wiley & Sons, (2006).
4. Electrochemical Systems, 3rd Edition J. Newman, Wiley-Inter science, (2004)
5. Modern Electrochemistry 2B: Electrodics in Chemistry, 2nd Edition, J. O'M. Bockris& A. K. N. Reddy, Engineering, Biology and Environmental Science, Springer, (2001).
6. Electrochemistry: Principles, Methods and Applications, C. M. A. Brett & A. M. O. Brett, Oxford University Press, (1993).
7. Laboratory Techniques in Electroanalytical Chemistry, 2nd Edition, P. Kissinger & W. R. Heinemann, CRS Press, (1996).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM Z321	CO1	3	2	2	1	3	1	2	2	2	1	3	3	3
	CO2	2	1	2	2	3	1	2	2	2	2	2	2	3
	CO3	3	3	2	2	2	1	1	2	2	2	2	2	3
	CO4	3	3	1	2	3	1	1	3	3	2	3	3	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ322	INSTRUMENTAL AND ANALYTICAL ANALYSIS TECHNIQUES-III.4	HC	4	0	0	4	4

Course Objectives:

This course aims to provide the student to:

i. Fundamental understanding of principles and their application of medical imaging techniques
ii. Understanding the optical microscopy and electron and ion beam microscopy
iii. To elucidate the chemical structure of molecules and compunds
iv. Developing the physical sensors for Specific applications

Course Outcomes:

By the completion of course student will be able to

CO1. Fundamental understanding of principles and their application of medical imaging Techniques.

CO2. Understanding the optical microscopy and electron and ion beam microscopy.

CO3. Understanding the structural elucidation by using different spectroscopic techniques.

CO4. Understanding and applications of different types of physical sensors.

Course Content:

UNIT-I

Advanced Imaging Techniques for Medical Applications

Basic principles, instrumentation and applications of different imaging techniques such as,Radio imaging, Ultrasound, Elastography, Radiography, Magnetic resonance imaging, Nuclear medicine, Photoacoustic imaging, Tomography, Echocardiography, IR imaging, Raman Imaging, X-ray imaging, CT Scan imaging, Magnetic resonance imaging. [8 **hrs]**

UNIT-II

Optical Microscopy- Basic principles, instrumentation and applications

Simple compound microspore, Fluorimetry, Confocal microscopy-multiphoton spectroscopy, single molecule spectroscopy

Electron microscopy- Basic principles, instrumentation and applications

Secondary electron microscopy, transmission electron microscopy, low energy electron diffraction (LEED), Focussed ion beam microscopy [7 hrs]

UNIT-III

Advanced Spectroscopy-Structural Elucidation

Spectroscopic methods for structure analysis using NMR (1H and 13C), Mass spectroscopy, IR, UV-Vis spectroscopy

1D NMR techniques: DEPT, Decoupling, magnetisation transfer, relaxation measurement, NOE difference spectra.

2D NMR techniques: Homo- and heteronuclear correlation (COSY, TOCSY, HMBC, HSQC,), measurement of the nuclear overhauser effect (NOESY, ROESY). **[7 hrs]**

UNIT-IV

Introduction to sensors, principle and uses of different transducers, Microelectromechanical systems (MEMS), nanoelectromechanical systems (NEMS).

Thermistor, thermocouple, resistance temperature detector, thermal imaging sensors, position sensor using Hall effect, proximity sensors: inductive & capacitive, accelerometer and vibration sensor, flow sensors, ultrasonic, laser sensors, touch sensors-capacitive and level sensors, actuators, piezoelectric sensors and piezoresistive actuators. Semiconductor gas sensors, electrochemical gas sensors, polymer gas sensors (Conductivity type) moisture sensor.

[8 hrs]

References:

1. Environmental Chemistry, Dr. H. Kaur, (2010).
2. Environmental pollution- monitoring and control, Khopkar. S. M, IIT Mumbai (2004).
3. Environmental Chemistry with Green Chemistry, Asim K. Das, (2010).
4. A text book of Soil Chemical Analysis, P. R. Hesse, (2002).
5. Environmental Chemistry, A. K. De, 7th Edition, Uttarpara West Bengal (2010).
6. Physico chemical examination of water, sewage and industrial effluents, 6th edition, N. Manivasakam, (2010).
7. Hand book of Analysis and Quality control for fruit and vegetable products, 2nd Edition, S Ranganna, Tata McGraw-Hill Publishing Co. Ltd.
8. Pharmaceutical Drug Analysis. AshutoshKar, New Age International Publishers.
9. Practical Clinical Biochemistry, 4th Edition, Harold Varley.
10. Food Analysis, A. G. Woodman, McGraw-Hill.
11. Principles of Medicinal Chemistry, Vol 1, Dr. S S, Kadam, Dr. K R Mahadic, Dr. K G Bothara, Niraliprakashan.
12. Modern Optical Spectroscopy, William W. Parson, Springer, Student Edn, (2009).
13. Principles of Fluorescence Spectroscopy, 3rd Edition, J. R. Lakowicz, Springer, (2006).
14. Laser Spectroscopy- Basic concepts and instrumentation – 3rd Edition, W. Demtroder, Springer, (2004).
15. Scanning Probe Microscopy and Spectroscopy, R. Wiesendanger, Cambridge University Press, (1994).

16. Handbook of instrumental techniques for analytical chemistry, Frank A. Settle, Prince Hall, New Jersey, (1997).
17. Physical chemistry of surfaces, Arthur W. Adamson (1990).
18. Introduction to Scanning Tunneling Microscopy, C. J. Chen, Oxford University Press, New York, (1993).
19. Gas Sensors, Principles, Operation and Developments, G. Sberveglieri, Springer, (1992).
20. Hand book of modern sensors, Physics, Designs, and Applications, Jacob Fraden, Springer, (2004).
21. Organic Spectroscopic Analysis, Editor: E W Abel, Rosaleen J. Anderson, David J. Bendell, Paul W. Groundwater, Royal Society of Chemistry, (2004).
22. Modern techniques of surface science, D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, (1994).
23. Introduction to Scanning Tunnelling Microscopy, C. J. Chen, Oxford University Press, New York, (1993).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ322	CO1	2	1		3	1						2	3	1
	CO2	3			3	1						3	3	1
	CO3	3			3	1						2	3	1
	CO4	3			3	1						2	3	1

SEMESTER-III: ANALYTICAL CHEMISTRY SOFT CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS304	ENVIRONMENTAL CHEMISTRY AND APPLIED ANALYSIS-III.5	DSEC*/HC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Demonstrate a knowledge and understanding of the basic facts and experimental basis of environmental chemistry.

ii. Develop an understanding of how chemists approach and attempt to solve environmental problems.

iii. Review the basic principles of analytical procedures to analyze food constituents and Evaluate quality control results and estimation of vitamins, lipids and other minerals.

iv. Describe the mechanism of drug molecules, principles and procedures of various tests performed in Clinical Chemistry laboratory.

Course Outcomes:

By the completion of course student will be able to

CO1. To create environmental awareness to understand the vulnerability and sensitivity of environment. To promote a sense of responsibility and proactive citizenship.

CO2. Recognize different types of toxic substances, their responses and analyze toxicological information and implement pollution monitoring techniques.

CO3. Illustrate the major chemical reactions occurring during processing and storage of food and method of analysis of various minerals in vitamins and also the estimation of lipids.

CO4. Construct the mechanism of drug interaction and interpretation of clinical data.

Course Content:

UNIT – I

Environmental Chemistry: Introduction: Environmental chemistry, environmental segments classification of environmental pollution.

Air Pollution: Introduction, Air pollutants, Primary pollutants, Sources (CO, NOx, HC, SO_2, and particulates). Particulates–Sources (Inorganicandorganicparticulate matters).

Effects on: Humans, materials, vegetationand animals. Air quality standards, Sampling, monitoring and analysis: CO by gas chromatography, NOx by Spectrophotometric method using sulphanilamide and NEDA, SO_2 by pararosaniline (PRA), H_2S by colorimetric using ethylene blue, hydrocarbons by chemiluminescence, control of air pollution: Control of particulate matter and gaseous pollutants.

Radioactive Pollution: Introduction, Sources, Radiation from natural and manmade activities, radioactive effects on human and plants, Storage and disposal of radioactive waste, Detection and monitoring of radioactive pollutants. **[8 hrs]**

UNIT-II

Water Pollution: Introduction, Sources, Water pollutants classification: Organic pollutants –Pesticides, insecticides, detergents. Inorganic pollutants, Sediments, Radioactive materials and Thermal pollutants. Drinking water supplies, Trace elements in water. COD, BOD, TOC-definitions. Monitoring techniques and methods: Determination of pH, conductance, dissolved oxygen by Winkler's method, nitrate/nitrite by diazo coupling, chloride by Mohrs and Volhard's method, and fluoride by Alizarin Visual method, Water contamination with cyanide, sulfide, sulphate, phosphate and total hardness. Analysis of Arsenic by Atomic absorption spectroscopy (AAS), cadmium and mercury by dithizone method, chromium by diphenyl carbazide method, lead by polarographic method. Water pollution control and management.

Soil Analysis: Introduction, Origin and nature of soil, Sources of soil pollution and explanation in brief, Purpose of soil analysis, Techniques for the analysis of soil Lime Potentials: Moisture measurement by gravimetric method, pH using calomel glass electrode method, total nitrogen by kjeldhal method, determination of nitrate nitrogen by Bratton and Marshal method, determination of potassium and sodium by Flame photometry, calcium by EDTA titration ,organic matter by combustion, total sulphur by oxidation as sulphate. **[7 hrs]**

UNIT - III

Food Analysis: Sampling, Preparation and storage of samples, Estimation of moisture, ash, crude protein, crude fat, sugars, nitrogen, crude fibre, starch in food. Polyphenols: Extraction, detection and analysis, characterization and spectral identifications of anthocyanins and anthocyanidins. Estimation of Tannins.

Vitamins: Estimation of Vitamin-C (Ascorbic acid), Thiamine, Riboflavin, Folic acid Minerals: Preparation of sample, Estimation of calcium, Magnesium, phosphorus, iron, potassium, sodium, copper, tin, zinc, lead, arsenic, mercury.

Lipids: General composition of edible oils, Physical and chemical characteristics. Composition and structure of free fatty acids. Test for the presence of specific oils: Ground nut oil, Sesame oil, cottonseed oil, linseed oil, argemone oil, presence of mineral oil, Fatty acid analysis. Estimation of fatty acid composition, tests for stability of fats. **[8 hrs]**

UNIT-IV

Analysis of Drugs: Drug design: Characteristics of an ideal drug molecule, mechanism of drug interaction, Antibiotics, classification and structure, mode of action, Theory and assay of Aspirin(titrimetry),

methyldopa (nonaqueous titrimetry), Analgin(iodimetry), chloral hydrate (argentiometry), cholesterol (gravimetry), hydrocortisone acetate (tetrazolium assay). Clinical Chemistry: Composition of blood, collection, and preservation of samples- anticoagulants, proteinprecipitants. Interpretationand Clinical analysis of Blood glucose (glucose oxidase methods), proteins, blood urea (Nesslerisation method). Lipids, Calcium, phosphorus, phosphatases, iodine, iron, copper, Sulfur, Magnesium, Chloride, sodium and potassium. **[7 hrs]**

References:

1. Environmental Chemistry, Dr. H. Kaur, (2010).
2. Environmental pollution- monitoring and control, Khopkar. S. M, IIT Mumbai, (2004).
2. Environmental Chemistry with Green Chemistry, Asim K. Das, (2010).
3. A text book of Soil Chemical Analysis, P. R. Hesse, (2002).
4. Environmental Chemistry, 7th Edition, A. K. De, Uttarpara West Bengal (2010).
5. Physico chemical examination of water - sewage and industrial effluents, 6th Edition, N. Manivasakam, (2010).
6. Hand book of Analysis and Quality control for fruit and vegetable products, 2nd Edition S Ranganna, Tata McGraw-Hill Publishing Co. Ltd.
7. Pharmaceutical Drug Analysis. AshutoshKar, New Age International Publishers.
8. Practical Clinical Biochemistry, 4th Edition, Harold Varley.
9. Food Analysis, A. G. Woodman, McGraw-Hill.
10. Principles of Medicinal Chemistry, Vol 1, Dr. S S, Kadam, Dr. K R Mahadic, Dr. K G Bothara, Niraliprakashan.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS304	**CO1**	3	3	1		1	3	3	1	1	3		1	
	CO2	1	3	2	2	1	1	1	1		1		1	1
	CO3	1	3	1	1	1	2	2			1	1	3	1
	CO4	1	2	3	3	3	1	1	1		1	2	3	2

OPEN ELECTIVE FOR PG STUDENTS OF DISCIPLINES OTHER THAN CHEMISTRY

(Offered to other Schools by Chemistry)

Course Code	**Course Title**	**Type**	L	T	P	C	Hrs/Week
M21SMO301	ADVANCED MATERIALS IN SEMICONDUCTOR DEVICE TECHNOLOGIES	OE	4	0	0	4	4

COURSE DETAILS: OE

Subject Nature: Theory

Prerequisites: Basics knowledge of Chemistry and Physics

COURSE OBJECTIVES:

This course enables the students to

1. Correlate the electronic properties of matter in device applications.
2. Provide insights on importance of selection of materials in device technologies
3. Understand the challenges of materials in energy and electronic devices.
4. Develop the knowledge and inspiration to look for new materials in advanced devices

COURSE OUTCOMES:

After the completion of the course, a student should be able to

1. Select materials for semiconductor devices.
2. Address the inherent challenges of semiconductor materials in device technologies.
3. Update with recent advances in semiconductors in device technologies
4. Apply the knowledge to extent and develop towards research on semiconductors

SYLLABUS

Unit 1: Electronic properties of matter: Electrons in matter, Band structure of solids, Energy bands, charge transport and ordering, Overview of materials preparation and fabrication techniques, solid-state electronics, emerging devices and crystalline materials: Atomic, molecular and polymeric systems

Unit 2: Advances of materials in Electronic and semiconductor devices: Semiconductor materials, Elements to compounds, Direct and indirect bandgap semiconductors, Materials challenges, Semiconductor devices,

Unit 3: Materials in photoconversion devices: Solar spectrum, solar energy conversion materials, inherent challenges, advanced materials, conversion efficiency, application, artificial photosynthesis, Photoelectrochemical devices, And Semiconductor/electrolyte charge transfer

Unit 4: Nanoelectronic and nanophotonic devices: Micro to nano devices transformation, Size effects, and nanoelectronic materials advances, Nanophotonics, Fabrications techniques, device challenges, device applications,

ESSENTIAL READING

1, Organic Electronics Materials and Devices, Springer Pub., S S Ogawa, 2015

2, Physical Chemsitry of Ionic materials, Wiley Pub. J Maier, 2004

3, Semiconductor devices: Physics and Technology, S. M Sze, M . K Lee, John Wiley and Sons, 2012

4.Photochemistry and photophysics: concepts, research and applications, Wiley Pub, V. Balzani, P. Ceroni, A. Juris, 2014

SUPPLEMENTARY READING

1. Journal reading, Nanoletters – ACS
2. Journal reading, Advanced materials – Wiley
3. Journal reading, Chemical Reviews - ACS

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3
M21SMO301	CO1	2	2	1	2	1	2			1	1	2	3	1
	CO2	2		2	1	1	1			1	0	1	2	2
	CO3	1		2	1	2	1			1		1	2	2
	CO4	2	1		1	2	1			1	1	1	3	1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMO302	BIODIESEL – AN ALTERNATE RENEWABLE ENERGY SOURCE	OE	4	0	0	4	4

Course Objectives: The open elective course aims to provide students about

1. Biodiesel as an alternate renewable energy source.
2. The chemistry concepts involved in understanding its fuel nature.
3. Raw materials and the constraints in their selection.
4. The analytical procedures and its engineering aspects.

Course Outcomes: After the completion of the course, students able to

CO1: Evaluate basic properties of oil/biodiesel labs.

CO2: Understand the experimental concepts, green techniques of biodiesel synthesis.

CO3: Realise the significance of spectroscopic techniques for sample characterisation.

CO4: Know correlation between biodiesel fuel properties and its engineering applications

Syllabus

Unit 1: Introduction to the basics

History of biodiesel, definition, basic structure of biodiesel molecule and its components, feedstocks-edible and non-edible, physical and chemical properties and their significance- acid value, free fatty acid, iodine value, peroxide value, saponification value, density, viscosity, cetane number (types), refractive index, fatty acid composition, structure of fatty acids and their chemistry, advantages and disadvantages of biodiesel, role of biotechnology, comparison of biodiesel with other alternate sources of energy, standard specifications (BSI, EN and ASTM).

Unit 2: Methods of synthesis

Methods of oil extraction- solvent extraction, mechanical, biodiesel synthesis- transesterification, pyrolysis, microwave technique, Ultrasonication and supercritical techniques, Experimental parameters; role catalyst– homogeneous (both acid & base), heterogeneous (both acid & base) catalysis, nature of alcohol and its effect (both advantages and disadvantages), chemistry of transesterification process, homogeneous and heterogeneous acid /base catalysis - reaction mechanism (some examples for homogeneous and heterogeneous catalysis)

Unit 3: Characterisation - Analytical techniques

Introduction to spectroscopic techniques of oil/biodiesel analysis; IR, NMR (IH and 13C) - basic principle, instrumentation and understanding of the chemistry of various functional groups, separation techniques of oil /biodiesel analysis; GC, HPLC - basic principle, instrumentation and chemistry involved in qualitative analysis and quantitative analysis.

Unit 4: Application of biodiesel as alternate fuel – engineering aspects

Basic concepts of CI engine, types of engines, combustion process in CI engine, engine performance parameters; BSFC, BP, BTE, and EGT, engine emission analysis of samples for CO_2, UHC, NOx, CO, PM, Soot and O_2 gases, and fuel-air ratio, alcohols as fuels; methanol, ethanol, and other higher alcohols, biodiesel as source of energy, role of blends as alternate fuels for CI engines (some examples), impact of FFA composition of fuel samples on engine performance and emission characteristics.

References

1. Biodiesel: A Realistic Fuel Alternative for Diesel Engines, Ayhan Demirbas, Springer Science & Business Media, 20-Dec-2007 - Technology & Engineering - 208 pages

2. Handbook of biofuels production: Processes and technologies, Rafael Luque, Juan Campelo, and JAMES Clark, Woodhead Publishing Limited, 2011

3. Biodiesel Handling and Use Guide *(Fifth Edition),* Teresa L. Alleman and Robert L. McCormick, US Department of Energy- Energy Efficiency and renewable energy

4. Biodiesel Production Technology, J. Van Gerpen, B. Shanks, and R. Pruszko, D. Clements, G. Knothe, National Renewable Energy Laboratory, Available electronically at http://www.osti.gov/bridge.

5. The Biodiesel Handbook- 2nd Edition, Gerhard Knothe Jürgen Krahl Jon Gerpen, Academic Press and AOCS Press, 1st May 2010

6. Introduction to Spectroscopy, Donald L Pavia, Gary M. Lampman, George S Kriz, Thomson Learning Academy resources

7. Fundamentals of molecular spectroscopy, Walter s. Struve, a wiley-interscience publication

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
M21S MO302	**CO1**	2	2				2		2			2	2	2
	CO2	2	2	3			3		3			2	2	3
	CO3	1	3				2		2			2	1	2
	CO4	2	2	3		2	3		3			2	2	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMO303	CHEMISTRY OF MATERIALS AND CHARACTERIZATION	OE	4		0	4	4

Course Objectives:

This course aims to provide the student to

i. Types of materials like layered materials and porous materials based on structure.

ii. The fundamentals of the chemistry of Nano materials its properties and applications.

iii. Synthesis the bulk materials by Precipitation methods, Sol – gel method, solid state synthesis and template technique.

iv. Characterize the samples by SEM, TEM, XPS and BET studies.

Course Outcomes:

By the completion of course student will be able to

CO1: Differentiate the Types of materials like layered materials and porous materials based on structure

CO2: Explainthe the fundamentals of the chemistry of Nano materials its properties and applications

CO3: Synthesize the bulk materials by Precipitation methods, Sol – gel method, solid state method and template technique.

CO4: Characterize the samples by SEM, TEM, XPS and BET studies.

Unit-I

Scope of materials science: Functional materials and their applications. Types of materials based on structure (i) layered materials (clays, MoS2, LDH) (ii) Porous materials: Microporous (zeolites), Mesoporous materials, (iii) Metal Organic Frameworks and dendrimers.

Unit-II

Nanomaterials: Introduction, properties of nanomaterials: (electronic, mechanical, superconducting, magnetic). Synthesis of nanomaterials: Top down methods (ball milling and exfoliation – thermal, solvent and interlayer modification) and bottom up methods (solution synthesis – La Mer principle, Ostwald ripening, role of capping agents, inverse micelle synthesis). Applications of Nanomaterials in medicine and biology – sensing and targeted drug delivery

Unit-III

Bulk materials: Bulk to nano transition - physical phenomena, Principle and applications, Synthesis methods (i) Precipitation methods (ii) Sol – gel method (iii) solid state synthesis (iv) template technique (v) Chemical vapor transport.

Unit-IV

Characterization techniques: Principle, technique and specific applications of Electron microscopy (TEM and SEM), Atomic Force Microscopy, Photoelectron spectroscopy (XPS and Auger spectroscopic techniques), BET surface area, porosity, solid state NMR (introduction).

Text Book Reference:

1. T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, Tata McGrawHill Publishing Company Limited NEW DELHI, 2007.
2. Nanomaterials Synthesis, Properties and Applications Edited by A S Edelstein and R C Cammarata, IOP Publishing Ltd 1996.
3. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press 2004.
4. Handbook of Nanoceramics and their Based Nanodevices (Vol. 2) Edited by Tseung-Yuen Tseng and Hari Singh Nalwa, American Scientific Publishers.
5. Neelina H. Malsch (Ed.), Biomedical Nanotechnology, CRC Press (2005).
6. P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, (2007).
7. W.N. Chang, Nanofibres fabrication, performance and applications, Nova Science Publishers Inc, (2009)

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3
M21SMO303	CO1	2	2	1	2	1	2			1	1	2	3	1
	CO2	1		1	1	1	1			1	0	1	2	2
	CO3	1		2	1	2	1			1		2	2	2
	CO4	1	1		1	2	1			1	1	1	3	1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMO304	CHEMISTRY OF FOOD AND BEVERAGES	OE	4	0	0	4	4

PREREQUISITES: Basics knowledge of Chemistry

COURSE OBJECTIVES:

This course enables the students to

1. Enhance the knowledge on the chemistry of food and beverages
2. Gather sufficient information about the resources and importance of diet
3. Assimilate the concepts of food processing
4. Develop the knowledge on bio-transformations and biochemical reactions

COURSE OUTCOMES:

After the completion of the course, a student should be able to

1. To acknowledge the dietary classifications and nutrients
2. Understand the significant aspects of food metabolism in the human body
3. Gain knowledge on the food quality and its impact on health
4. Realize the various aspects of food storage and preservation, toxins and contaminants.

SYLLABUS

Unit 1

Food, Types of nutrients, Food as a source of energy, Use of energy by the body, Energy requirements, Enzymes, Cell metabolism, Digestion, Deficiency diseases, Concept of a balanced diet, Diet and diseases of affluence, Concepts of health and food quality, Regulation of appetite and eating, Metabolism and the role of diet in regulation, Obesity, Anorexia nervosa, Food intolerance and allergy, Dietary reference values, Uses of dietary reference values, Coeliac disease, Oils and fats, Lipids in aqueous media: colloidal and emulsions, Lipids in the diet.

Unit 2

Milk and dairy products, Nutritional value, Sugars, Polysaccharides, Carbohydrates in the diet, Carbohydrates in the body, Sources of sugars, Sucrose, Cane sugar or beet sugar, Foodstuffs manufactured from sugar, Sugars in the diet, Cereals, Amino acids, Peptides, Proteins, Meat, Fish, Eggs, Soya, Novel protein-rich foods.

Unit 3

Water, Non-alcoholic beverages, Alcoholic beverages, Major mineral elements, Other mineral elements, Fat-soluble vitamins, Water-soluble vitamins, Other bioactive food constituents, Plant polyphenols, Fruits, Nuts, Vegetables, Sensory qualities of fruits and vegetables, Bioactive compounds in fruits and vegetables.

Unit 4

Cooking, Methods of heat transfer, Transfer of mass, General effects of cooking, Changes occurring after cooking , Moist heat methods, Dry heat methods, Raising agents, The nature of diet, Establishing diet and health links, Dietary needs of special groups, Types of dietary intervention to improve health, Food spoilage, Food preservation, Food toxins, Food hygiene, Food contaminants, Food additives

ESSENTIAL READING

1. Food Chemistry, Belitz, H.-D., Werner Grosch, Peter Schieberle, Springer 2009

2. Principles of Food Chemistry, John M. deMan, Third Edition, Aspen Publication 1999

3. Introduction to Food Chemistry, Richard Owusu-Apenten, CRC Press, 2019

Food Science, Nutrition and Health, Michael E. J. Lean CRC Press 2006

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3
M21SMO304	**CO1**	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**0**	**0**	**1**	**3**	**1**	**2**
	CO2	**3**	**2**	**1**	**2**	**2**	**3**	**2**	**0**	**0**	**1**	**2**	**1**	**3**
	CO3	**2**	**3**	**2**	**3**	**3**	**2**	**1**	**0**	**0**	**1**	**3**	**1**	**2**
	CO4	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**0**	**0**	**1**	**3**	**1**	**3**

Course Code	**Course Title**	**Type**	L	T	P	C	Hrs/Week
M21SMO305	NANOTECHNOLOGY	OE	2	0	0	2	2

This is the fundamental course in Nanotechnology. This course will provide the Nanotechnology needed to understand engineering applications. This course will be begun by covering the nanotechnology concepts necessary in the study of recent advancement technology. Next, it covers the concepts of smart materials for device applications. Fatherly, it discusses the concepts of fabrication of instruments. Then move on to nano characterization devices analyze the nano structures using the optical, X-ray and electron beam techniques. Finally, it covers the topics of nanofabrication devices, properties and nano characterizations.

Course Objectives:

This course aims to provide the student to:

This course enables graduating students to identify Nanotechnology requirements and to find efficient solutions in developing smart materials for device applications.

i. Learn on basic introduction to nanomaterials and their fabrications
ii. Classification of nanomaterials and their working principle.
iii. Discuss the preparation of nanomaterials.
iv. Gain the knowledge of nanomaterials and their applications.

Course Outcomes:

By the completion of course student will be able to

CO1: Understand the importance of nanotechnology and properties

CO2: Provide knowledge on fabrication of nanomaterials

CO3: Provide knowledge on Characterization of nanomaterial

CO4: Apply the nanotechnology and device for fabrication of smart devices and industrial applications.

Course Content:

UNIT-I

Introduction to nanotechnology: Nanomaterials, size dependent properties, nanotechnology**,** bottom up and top-down approaches for the synthesis of nanomaterials. Cleanroom and vacuum environment are necessary for creating nanotechnology products.

Properties of nanomaterials and devices applications: Photocatalytic, Thermal, Magnetic, Optical, Mechanical, and Electrical properties.

UNIT-II

Nanofabrication techniques: basics of nanofabrication, Powder Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), Molecular beam epitaxy, Template based synthesis, Gas phase, Plasma-based synthesis, and Lithography.

Nanostructures and device applications: Carbon fullerenes, graphene, CNT, metal, metal oxides, semiconducting quantum dots, nanowires, and nanocomposites.

UNIT-III

Nanomaterials characterization devices and techniques: Principle, instrumentation, and structural analysis of scanning electron microscopy (SEM) and transmission electron microscopy (TEM), scanning probe microscopy: atomic force microscopy (AFM) and scanning tunneling microscopy (STM), and X-ray photoelectron spectroscopy.

UNIT-IV

Industrial Nanotechnology: Nanoelectronics devices, Nanorobotics in Surgery -Nanosensors in Diagnosis- Neuro-electronic Interfaces- Therapeutic applications, Polymer nanofibers – Nylon-6 nanocomposites from polymerization -Nano-filled polypropylene fibers – Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes). Nanomaterials composite for agricultures.

Text Book Reference:

1. T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, Tata McGraw Hill Publishing Company Limited NEW DELHI, 2007.
2. Nanomaterials Synthesis, Properties and Applications Edited by A S Edelstein and R C Cammarata, IOP Publishing Ltd 1996.
3. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press 2004.
4. Nanomaterials, Nanotechnologies and Design: An Introduction to Engineers and Architects, D. Michael Ashby, Paulo Ferreira, Daniel L. Schodek, Butterworth-Heinemann, 2009.
5. Handbook of Nanoceramics and their Based Nanodevices (Vol. 2) Edited by Tseung-Yuen Tseng and Hari Singh Nalwa, American Scientific Publishers.
6. Neelina H. Malsch (Ed.), Biomedical Nanotechnology, CRC Press (2005).
7. P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, (2007).
8. Y-W. Mai, Polymer Nano composites, Woodhead publishing, (2006).
9. W.N. Chang,Nanofibres fabrication, performance and applications, Nova Science Publishers Inc, (2009)

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MO305	CO1	2			1	1	1				1	1	1	2
	CO2	2			1	1	1				1	1	1	2
	CO3	2			1	1	1				1	1	1	2
	CO4	2			1	1	1				1	1	1	2

Course Code	Course Title	Type	L	T	P	C	CH
M21SMO306	**Sensor Technologies: Physical Sensors, Chemical Sensors, Biosensors, Gas Sensors and their Instrumentation**	**OE**	**4**	**0**	**0**	**4**	**4**

CoM21urse Objectives: This course aims to provide the student to

v. *Learn on basic introduction to Sensors and their fabrications*
vi. Classification of Physical Sensors and their working principle.
vii. Discuss the Chemical and Biosensors and their classifications.
viii. Gain the knowledge of gas sensors and their applications.

Course outcomes: After completion of this course student shall able to

1. Discuss the fabrication of sensors.
2. Explain the various typesPhysical Sensors and their working principle
3. Differentiate the Chemical and Biosensors and their classifications.
4. Construct the gas sensors and explain their applications.

Course Description:

Sensor course will provide students about comprehensive understanding of different types of sensors and their underlying principles. The basic knowledge of construction of sensors, selection of suitable sensor for particular application, calibration methods and their principles. Theory and application of various sensor technologies and their instrumentation.

Unit I **13 Hours**

Techniques of sensor fabrications

Basic construction of sensors.Thin Film Deposition Techniques: Physical Vapor Deposition Thermal Deposition, E-beam Evaporation, Sputtering (RF Sputtering), Pulsed Laser Deposition, Field effect Transistors. Chemical vapour deposition techniques. Basic understanding of Photolithography (Photolithography) for pattering layer. Chemical synthesis-solgel technique.

Etching methods for fabrication, Microfluidics design and sensor applications using PDMS technique. Patterning and lithography for nanoscale devices: Introduction to optical/UV, electron beam and X-ray Lithography systems and processes, Wet etching, dry (Plasma /reactive ion) etching, Etch resists-dip pen lithography.

Unit II **13 Hours**

Physical Sensors

Temperature Sensors: Thermistor, Thermocouple, Resistance temperature detector, thermal imaging sensors, position sensor using Hall effect, Proximity sensors: Inductive & Capacitive, accelerometer and vibration sensor, Flow Sensors, ultrasonic and laser sensors- Capacitive and level sensors. Working principles of Actuators, Piezoelectric and Piezoresistive actuators, MEMS, NEMS.

Unit III **13 Hours**

Chemical sensors and Biosensors

Basic principles of chemical and biosensors, different types of biosensors validation methods and their applications. Protein/enzyme based sensors, immobilization techniques, specificity of sensors, binding constants, kinetics and diffusion constants. Redox-enzymes in biosensors, amperometric methods and conductometric methods. Application of quartz crystal microbalance. Optical biosensors UV/Vis/IR, luminescence, fluorescence, fibre optic sensors, surface plasmon resonance sensors, Transducers-electrochemical and optical devices.

Unit IV **13 Hours**

Gas sensors, metal ion sensors, and their fabrication, sensor characteristics and failure mechanisms

Optical gas sensors, semiconductor gas sensors, electrochemical gas sensors, polymer gas sensors (Conductivity type) Moisture sensor.

Heavy metal ion sensors: Optical method of detection, electrochemical methods of detection and heavy metal ion remedies

Basics and fundamental Measurement: Classification of errors, Error analysis – Static and dynamic errors, Sensor Characterisation and Calibration: Static and Dynamic Characteristics of sensors, reliability, aging test, failure mechanisms, stability studies and their evaluation. Physics and chemistry of nanotechnology process of sensors.

References

8. Nanofabrication towards biomedical applications, C.S.S.R. Kumar, J.Hormes, C.Leuschner, Wiley –VCH Verlag GmbH & Co, Weinheim, (2004).
9. Nano Electronics and information Technology, W. Rainer, Wiley, (2003).
10. Transducers and Instrumentation, D.V.S. Murty, 2nd edition, (2012)
11. Measurement, Instrumentation, and Sensors Handbook, John G. Webster, HalitEren, CRC Press, (2018)
12. Handbook of Modern Sensors, Fraden, Jacob, Springer-Verlag New York (2010).

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
M21SMO306	CO1	3	1	1	2	1	1	0	0	1	1	2	3	1
	CO2	1	0	1	1	1	1	0	0	1	0	1	2	2
	CO3	1	0	1	1	1	1	0	0	1	0	1	2	2
	CO4	1	1	1	1	1	1	0	0	1	1	1	3	1

SEMESTER-III

INTERNSHIP / SKILL DEVELOPMENT

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SMM321	INTERNSHIP / SKILL DEVELOPMENT	RULO	0	0	2	0	4

Note: The students will have to undergo Skill Development course being conducted by Training and Placement cell of the University.

SEMESTER-III: INORGANIC CHEMISTRY PRACTICAL-1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ305	INORGANIC CHEMISTRY PRACTICALS-III.1	SC	0	0	2	2	4

Course Objectives:

This course aims to provide the student to

i. The practical course on Inorganic chemistry intends to provide the students scientific skills in qualitative and preparative techniques.

ii. Appreciate the importance of being systematic in life.

iii. It also helps to develop honesty, punctuality, analytical reasoning, questioning, critical evaluation and thinking among students.

Course Outcomes:

By the completion of course student will be able to

CO1. Apply the practical knowledge in determination of strength of analyte.

CO2. Identify individual functional groups present in mixture of salt.

CO3. Detect the ions present in the sample by different techniques.

CO4. Estimate the amount of ions by volumetric and gravimetric methods.

Course Content:

PART – I

1. Simultaneous spectrophotometric determination of chromium and manganese in a steel solution.
2. Quantitative analysis of copper (II) and iron (II) in a mixture:
    i. Copper gravimetrically as CuSCN and
    ii. Iron volumetrically using cerium (IV) solution
3. Flame photometric determination of the following metal ions from different samples:
    a) Sodium
    b) Potassium
    c) Calcium
    d) Lithium and
    d) Sodium and potassium in a mixture.
4. Quantitative determination of nickel using dithizone and 1, 10-phenanthroline by synergistic extraction.
5. Spectrophotometric determination of the pKa value of methyl red.
6. Micro-titrimetric estimation of: a) Iron using cerium (IV), b) Calcium and magnesium using EDTA

7. Quantitative estimation of copper (II), calcium (II) and chloride in a mixture.

COMPLEX ANALYSIS

1. Estimation of cobalt present in Chloropentamminecobalt (III) chloride complex.
2. Estimation of nickel present in Hexamine nickle(II)chloride complex

ORE ANALYSIS

1. Estimation of calcium carbonate in limestone by oxalate method.
2. Estimation of MnO_2 present in the given pyrolusite ore.
3. Estimation of Chromium and manganese in steel sample.
4. Estimation of Iron in pharmaceutical samples.

PART – II

COMPLEX PREPARATIONS

1. Preparation of Mercury tetrathiocyanato cobaltate (II) complex.
2. Preparation of Chloropentammine cobalt (III) chloride complex.
3. Preparation of Bisoxalato cuprate (II) di hydrate complex.
4. Preparation of Tris-oxalato ferrate (III) complex.
5. Preparation of Sulphato tristhiourea zinc (II) complex.
6. Preparation of Tristhiourea copper (I) sulphate complex
7. Cis and Trans Diaquadioxalato chromate (III) complex.
8. Preparation of Hexamine nickle (II) chloride complex.
9. Demonstration Experiments:
    (a) Interpretation of IR and NMR spectra of complexes.
    (b) DNA interaction with metal complexes by UV-visible absorption and viscosity methods.
    (c) Preparation of Metal oxide-conducting polymer composite
10. Characterization of any one inorganic metal complexes: conductance method, cryoscopy, IR spectroscopy, EPS, QPS, X-ray diffraction, Dipole moment, NMR spectroscopy, Chemical methods, Mossbauer spectra.
11. Characterization of any one inorganic compounds by XRD, IR, UV-Vis, SEM, TEM, AFM, STM, XANS, LEED, AAS, ICP-AES, TDS, SIMS, and Chromatographic analysis.

References:

1. Advanced Physico-Chemical Experiments, J. Rose.
2. Instrumental Analysis Manual - Modern Experiments for Laboratory, G. G. Guilbault and L. G.

Hargis.
3. A Text Book of Quantitative Inorganic Analysis, A.I. Vogel, 5th edition.
4. Experimental Inorganic Chemistry, G. Palmer.
5. Inorganic Synthesis, O. Glemser.
6. Experimental Inorganic/ Physical Chemistry, Mounir A. Malati.
7. Quantitative Chemical Analysis, 7th Edition,Daniel C. Harris, (2006).
8. Spectrophotometric Determination of Elements, Z. Marczenko.
9. College practical Chemistry, Ahulwalia.
10. Analytical Chemistry, G. D. Christian.
11. Practical Inorganic Chemistry, K. Somashekara Rao.
12. Principles of Inorganic Chemistry, Puri, Sharma, Khalia.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM Z305	CO1	3	2	2	2	3	2	2		1	2	3	2	2
	CO2	3	2	2	2	2	2	2	2	1	2	3	2	2
	CO3	2	2	2	3	2	1	2	2	2	2	2	2	2
	CO4	2	3	3	2	2	2	2	2	1	2	2	3	3

SEMESTER-III: ORGANIC CHEMISTRY PRACTICAL-1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ311	ORGANIC CHEMISTRY PRACTICAL –III.1	DSEC/SC	0	0	2	2	4

Course Objectives:

This course aims to provide the student to

i. Practical knowledge on organic chemistry and scientific skills in qualitative and preparative techniques.
ii. Acquire the experience of handling the chemicals and their identification through chemical analysis.
iii. Appreciate the importance of being systematic in life.
iv. Helps to develop punctuality, analytical reasoning, questioning, critical evaluation and thinking.

Course Outcomes:

By the completion of course student will be able to

CO1. Acquire skill to perform chemical reaction, common laboratory techniques, including reflux, distillation, steam distillation, re-crystallization, vacuum filtration and aqueous extraction.

CO2. Calculate the limiting reagent and percent yield.

CO3. Evaluate data collected to determine the identity, purity, and yield of products, and to characterize organic molecules by physical methods such as melting point and boiling point.

CO4. Predict the outcome and mechanism of some simple organic reactions, using a basic understanding of the relative reactivity of functional groups.

Course Content:

Organic Chemistry Practicals - II

Qualitative analysis Systematic analysis and identification of organic compounds.

References:

1. Vogel's Text Book of Practical Organic Chemistry, 5th Edition, Brian S. Furniss, Antony J. Hannaford, Peter W. G. Smith, Austin R. Tatchell, Longman Scientific and Technical, (1989).
2. Some modern methods of Organic Synthesis, 2nd Edition,W. Caruthers, Cambridge Uni. Press London, (1998).
3. Organic synthesis: Special techniques, K. Ahluwalia and R. Aggarwal, Narosa, New Delhi, (2003).
4. Spectrometric Identification of Organic Compounds, R. M. Silverstein and W. P. Webster, Wiley & Sons, (1999).

5. Introduction to Spectroscopy, 3rd Edition, Pavia, Lampman and Kriz, Thomson.

Mapping of Course Outcomes with programme Outcomes (sample)

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ311	CO1	3	2	1	3	2		3			1	3	3	2
	CO2	2	2	1	3	1	1	1		3	1	3	2	2
	CO3	2	2	2	3	2	2	2		2	1	3	2	2
	CO4	2	2	1	1	2	1				1	3	2	1

SEMESTER-III: ANALYTICAL CHEMISTRY PRACTICAL-1

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ323	ANALYTICAL CHEMISTRY PRACTICAL –III.2	SC	0	0	2	2	4

Course Objectives:

The practical course on Analytical chemistry intends to provide the students to,

i. Impart training in operating different instruments used in the analysis of chemical constituents.
ii. Analyze different chemical constituents using various analyticalmethods.
iii. Explain diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.
iv. Provide a basic knowledge and understanding of essential chemical and physical principles for analytical chemistry.

Course Out comes:

On successful completion of the practical course students shall be able to:

CO1. Demonstrate practical skills in analysing different constituents using instrumental methods.
CO2. Employ a variety of analytical and instrumental methods to prepare, separate and quantify Samples.
CO3. Describe and compare a range of electroanalytical methods and explain the underlying Theoretical principles.
CO4. Defend the experimental results with validation.

Course Content:

1. Estimation of acetyl salicylic acid in the given aspirin tablet by titrating against 0.1N alcoholic KOH potentiometrically.
2. Determination of strength of acetic acid (commercial vinegar) by Conductometric method.
3. Determination of purity of commercial HCl, H_2SO_4, H_3PO_4 and CH_3COOH and using pH metric end point.
4. Estimation of sulphate as benzidine sulphate by potentimetric method.
5. Estimation of metal acetates using perchloric acid in glacial acetic acid medium.
6. Estimation of copper using salicylaldoxime.
7. Estimation of Iron III by solvent Extraction.
8. Synthesis of inorganic polymer and measurement of surface acidity and basicity.

9. Analysis of chrome steel: Estimation of iron by volumetry and Cr by colorimetry.
10. Determination of pKa of a weak organic acid or a base using UV-Vis spectrophotometry.
11. Analysis of Portland cement: Estimation of insoluble residue by gravimetry.
12. Standardizing cyclic voltammetry using ferrocyanide—ferriccyanide system.

References:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, Third Indian Reprint, Pearson Education Pvt. Ltd., New Delhi, (2003).
2. Analytical Chemistry Principles, 2nd Edition, John H. Kennedy, Saunders College Publishing, California, (1990).
3. Analytical Chemistry: An introduction Skoog, West, Holler and Crouch; 7th Edition Saunders College Publishing, (1999).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM Z323	CO1	3	3	3	3	3	2	1	1	1	2	2	3	2
	CO2	3	3	2	3	3	2	1	2	1	2	2	2	2
	CO3	2	3	2	2	3	2	1	1	1	2	3	2	3
	CO4	2	2	2	2	2	2	2	1	1	2	2	2	2

SEMESTER-III: INORGANIC CHEMISTRY PRACTICAL-2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ306	ADVANCED INORGANIC CHEMISTRY PRACTICALS-III.2	SC	0	1	2	2	4

Course Objectives:

The practical course on Inorganic chemistry intends to provide the students scientific skills in qualitative and preparative techniques.

i. Appreciate the importance of being systematic in life.

ii. It also helps to develop honesty, punctuality, analytical reasoning, questioning, critical evaluation and thinking among students.

Course Outcomes:

On successful completion of course students will be able to:

CO1. Apply the practical knowledge in determination of strength of analyte.

CO2. Identify individual functional groups present in mixture of salt.

CO3. Detect the ions present in the sample by different techniques.

CO4. Estimate the amount of ions by volumetric and gravimetric methods.

Course Content:

PART-I

COMPLEX ANALYSIS

1. Determination of CFSE. for select transition metal complexes
2. Rate of isomerization of trans-potassium dioxalatodiaquachromate(I1I) to the cis isomer
3. Preparation of Iodine pentoxide,
4. Preparation of potassium trioxalatomanganate (III) from higher oxidation state. Preparation of potassium manganate from Potassium permanganate
5. Solvent effect in UV-Vis spectra on transition metal complexes
6. IR spectra of Coordinationcomplexes
7. Kinetics of Malachite green or dye discoloration
8. Preparation and spectral characterizationof,

NiO, Nickel ferrite, trans-$[Co(en)_2Cl_2]Cl$, $K_3[Cr(ox)_3]$ $(NH_4)_3[Cr(ox)_3]$ $[Cu(acac)_3]Mn(acac)_3]$ $[Cu(thiourea)_3]_2SO_4$, Copper phthalocyanine, copper-1,10-phenanthroline

9. Stabiliation of oxidation states in copper (I) chloride, copper(I) tetraiodomercurate(II), tris(thiourea)copper(I) sulphate, tetrapyridinesilver(II) peroxodisulphate

PART-II

COMPLEX PREPARATIONS

1. Preparation of Sulphatotristhioureazinc (II) complex.
2. Cis and Trans Diaquadioxalatochromate (III) complex.
3. Estimation of nickel present in Hexamine nickle (II) chloride complex

ORE ANALYSIS

1. Estimation of calcium carbonate in limestone by oxalate method.
2. Estimation of MnO_2 present in the given pyrolusite ore.

COMMERCIAL SAMPLE ANALYSIS

1. Estimation of Chromium and manganese in steel sample.
2. Estimation of Iron in pharmaceutical samples.

LAB ASSIGNMENTS

1. Characterization of any one inorganic metal complexes: conductance method, cryoscopy, IR spectroscopy, EPS, QPS, X-ray diffraction, Dipole moment, NMR spectroscopy, Chemical methods, Mossbauer spectra.
2. Characterization of any one inorganic compounds by XRD, IR, UV-Vis, SEM, TEM, AFM, STM, XANS, LEED, AAS, ICP-AES, TDS, SIMS, and Chromatographic analysis.

References:

1. Vogel's Textbook of Quantitative analysis, 6th Edition, J Mendham, R.C. Denney, J. D. Barnes M. J. K. Thomas.
2. College practical Chemistry, Ahulwalia.
4. Analytical Chemistry, G.D. Christian.
5. Practical Inorganic Chemistry, K. Somashekara Rao.
6. Principles of Inorganic Chemistry, Puri, Sharma, Khalia.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM Z306	CO1	3	2	2	2	3	2	2		1	2	1	2	2
	CO2	3	2	2	2	2	2	2	2	1	2	2	3	2
	CO3	2	2	2	3	2	1	2	2	2	2	2	2	3
	CO4	2	3	3	2	2	2	2	2	1	2	2	2	2

SEMESTER-III: ORGANIC CHEMISTRY PRACTICAL-2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ312	ADVANCED ORGANIC CHEMISTRY PRACTICAL –III.2	DSEC/SC	0	1	2	2	4

Course Objectives:

This course aims to provide the student with

i. Practical knowledge on protection and deprotection.
ii. Ability to choose feasible reactions and optimize the yield.
iii. Experience on Reagent control and functional group transformation.
iv. Awareness on ecofriendly conditions and chemical waste management.

Course Outcomes:

By the completion of course student will be able to

CO1. Explore the suitable reactions for carbon-carbon and carbon-heteroatom bond formation.
CO2. Protect and deprotect the functional groups that interfere with the reaction conditions.
CO3. Incorporate chemoselectivity and regioselectivity controls in chemical synthesis.
CO4. Devise economical and highly efficient linear or convergent synthesis, and multicomponent reactions.

Course Content:

Organic Chemistry Practicals - III

1. Green synthesis and reactions.
2. Protection and deprotection reactions of organic multiple functional groups.
3. Multiple step synthesis involving functional group transformations.
4. Isolation and purifications of organic compounds-TLC, Column Chromatography and using Rotatory evaporators.
5. Spectral characterisation of organic compounds.

References:

1. Green Chemistry-Environmentally benign recations, V.K Ahluwalia. Ane Books India (Publisher) (2006).

2. Green Chemistry-Designing Chemistry for the Environment, 2nd Edition, Edited by Paul T. Anastas & Tracy C. Willamson (1998).
3. Some modern methods of Organic Synthesis, 2nd Edition,W. Caruthers, Cambridge Uni. Press London, (1998).
4. Organic synthesis: Special techniques, V. K. Ahluwalia and R. Aggarwal, Narosa, New Delhi, (2003).
5. Spectrometric Identification of Organic Compounds, R.M. Silverstein and W.P. Webster, Wiley & Sons, (1999).
6. Introduction to Spectroscopy,3rd Edition, Pavia, Lampman and Kriz, Thomson.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MZ312	CO1	1	3		3	3						2	3	2
	CO2	3	1	3		3	3						1	3
	CO3	2	2		3	3						3	3	2
	CO4	3	3	2	2	2						1	1	1

SEMESTER-III: ANALYTICAL CHEMISTRY PRACTICAL-2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMZ324	ANALYTICAL CHEMISTRY PRACTICAL –III.2	SC	0	0	2	2	4

Course Objectives:

The practical course on Analytical chemistry intends to provide the students to,

i. Learn different electro analytical techniques for sample analysis.
ii. Impart training in practical experience in selected instrumental methods of analysis.
iii. Able to synthesize materials, characterization and chemical analysis.
iv. Understanding the theoretical principles and practical applications of different chromatographic techniques.

Course Out comes:

On successful completion of the practical course students shall be able to:

CO1. Interpret the results of quantitative experiments and interpret the data in meaningful ways.

CO2. Analyze the chemical methods employed for compound analysis.

CO3. Illustrate the experimental skills on different instrumental analysis of the given compounds.

CO4. Discuss the fundamentals, critical thinking and analytical reasoning as applied to scientific problems.

Course Content:

1. Determination of fluoride in drinking water by Spectrophotometry (Zr-Alizarin method).
2. Estimation of caffeine in a given sample using UV Spectrophotometer.
3. Spectrophotometric determination of pKa value of an indicator (the acid dissociation constant of methyl red).
4. Separation and identification of metal ions in a mixture by paper chromatography/TLC.
5. Synthesis of CaO and MgO composites and their characterization by XRD studies.
6. Preparation of Hexamine nickel (II) chloride complex and its characterization by IR Spectroscopy.
7. Synthesis of dipeptide and its characterization by IR Spectroscopy.
8. Preparation of Aspirin and its characterization by NMR Spectroscopy.
9. To determine the percentage of ascorbic acid in a given sample using HPLC.

References:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, Third Indian Reprint, Pearson Education Pvt. Ltd., New Delhi,(2003).
2. Analytical Chemistry: An introduction Skoog, 7th Edition, West, Holler and Crouch, Saunders College Publishing (1999).
3. Chromatography, C. G. Sharma.

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ Cos**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21SM Z324	CO1	2	3	3	3	3	3	3	3	1	2	2	3	3
	CO2	2	3	3	3	2	2	3	1	2	2	2	3	3
	CO3	2	2	2	2	3	3	2	2	1	1	2	3	3
	CO4	3	3	3	3	2	2	1	2	1	3	2	3	3

SEMESTER-IV: HARDCORE

Course Code	Course Title	Type	L	T	P	C	Hrs./
M21SM0401	MAJOR PROJECT	HC	0	0	8	8	16

Course Objective:

To carry out the research under the guidance of R&D supervisor/Industry/R&D Institution and in the process learn the techniques of research.

Course Outcomes:

On successful completion of the project, the student shall be able to:

- **CO1.** Familiarize with literature search
- **CO2.** Conduct the experiments related to research and formulate computational techniques.
- **CO3.** Interpret the scientific data
- **CO4.** Write report and defend the research findings.

Course Content:

Project:

This project will be based on preliminary research-oriented topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the student. The research projects floated should be completed in 18 weeks. After the completion of the project the student shall submit project report in the form of dissertation on a specified date by the School. The details of assessment of project are explained under the heading “Evaluation of Minor Project / Major Project / Dissertation” in this handbook.

SEMESTER-IV: SOFT CORE

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS401	FUNCTIONAL INORGANIC MATERIALS	SC	2	0	0	2	2

Course of Objective:

This course aims to provide the student to

i. Explain the basic concept the inorganic based metal complexes.
ii. Elaborate the synthesis, reaction, properties and applications of magnetic materials.
iii. Discuss the crystalline inorganic metal oxide for the structural correlation with properties.
iv. Explain the various superconductors for the device application.

Course of Outcome:

By the completion of course student will be able to

CO1. Build the knowledge on inorganic based metal complexes.
CO2. Importance of magnetic materials and their application in various sector.
CO3. Interpretation of metal oxide with the help of structure-property correlations and potential applications.
CO4. Design the superconducting materials based on the device application.

Course Content:

UNIT -I

Macrocyclic inorganic complexes, supramolecular organometallic compounds, Metalloorganic frameworks and metallopolymers. **[12 hrs]**

UNIT -II

Metallomesogens – synthesis, properties, applications, Molecular Magnetic materials, GMR materials, Compounds intercalation and redox reactions. **[12 hrs]**

UNIT -III

Synthesis, structure, properties, structure-property correlations and potential applications of crystalline inorganic solid state materials. Functional oxides, mixed metal oxides.

[12 hrs]

UNIT -IV

Superconductors –(Ba,K)BiO3, Cuprates, MgB2, , Ferroelectric materials, Piezoelectric materials, ionic conductors, Spintronics Materials – Principle, Synthesis – Gas storage materials, Photoluminescent materials. **[12 hrs]**

References:

1. Principles of Inorganic Materials Design,J. N. Lalena, D.A. Cleary, Wiley, New York, (2010).
2. Physical Chemistry of Ionic Materials: Ions and Electrons in Solids, Maier, J. Wiley, New York, (2004).
3. Solid-state Chemistry of Inorganic Materials VI (Symposium QQ at 2006 MRS Fall Meeting), Curran Associates, Inc., (2007).
4. Supramolecular Chemistry,P. D. Beer, P. A. Gale, D. K. Smith, Oxford University Press, (1999).
5. Supramolecular Chemistry, J. W. Steed, J. L. AtwoodWiley, (2000).

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ Cos**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21S MS401	CO1	2	3	1	2	3				1	2	3	2	3
	CO2	3	3	1	2	3	2			1	2	3	3	3
	CO3	3	3		2	2				1	2	3	3	3
	CO4	3	2	1	2	3	1			1	2	3	4	3

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS402	ADVANCED FUNCTIONAL ORGANIC MATERIALS	DSEC/SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. To develop the knowledge of functional organic materials, organic optical devices.
ii. Apply the synthetic organic chemistry knowledge in making MOF's and organic electronic devices, solar devices.
iii. To understand the application of organic materials in the area of organic electronics, metal organic frameworks, optical materials and in solar cells.
iv. To construct the materials based on their requirement like solar cells, OLEDs, energy storage devices etc.

Course Outcomes:

By the completion of course student will be able to

CO1. Acquire knowledge on functional organic materials as molecular spintronic.
CO2. Understand the applications of MOFs as energy materials etc.
CO3. Categorize the optical materials for OLED´s.
CO4. Application of organic materials for solar cells.

Course Content:

UNIT-I

Functional organic materials: Introduction to material science. Classification and examples of application of functional (in) organic molecules.

Organic electronics: Electron transport in organic mat erials. (A) Chiral organic (supra) conductors. Molecular spintronics–classification, concepts, materials and applications. **[7 hrs]**

UNIT-II

Metal-organic frameworks: Definition, nomenclature and classification of metal-organic frameworks (MOF´s). Synthesis, physico-chemical properties and catalytic applications. Molecules encapsulation in MOF´s and its applications – molecular gas cylinders (hydrogen, methane, acetylene), drug carriers (ibuprofen). Nanotechnologies based on MOF´s. **[8 hrs]**

UNIT-III

Non-linear optical materials: Principles of fluorescence and phosphorescence. Organoluminescence – classification, chemistry and applications. Organic light-emitting diodes (OLED´s). Polymeric opto-elektronic materials. Electroluminescence, mechanochromic fluorescence and piezofluorochromism – concepts, materials and future applications. **[8 hrs]**

UNIT-IV

Solar cells: Photoelectric effect. Basic principles of organic solar cells. Dye-sensitised solar cells (DSSC) – classification, concepts, chemistry and applications. Organic photovoltaics. Chemistry of personalized solar energy. [7 **hrs]**

References:

1. Functional organic materials: synthesis, strategies and applications, Thomas J. J Muller, Wiley-VCH (2007).
2. The chemistry of metal-organic frameworks synthesis, characterization and applications, Edited by Stefan Kaskel, Wiley-VCH, (2016).
3. Organic photovoltaics-mechanisms, materials and devices, Sam-Shajing sun. Niyai serdar Sariciftci, March 29, CRC press, (2005).
4. Research articles and reviews published in reputed journals.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS402	CO1	3		1	2							3	2	2
	CO2	1	1	2			3					3	2	1
	CO3	2		2	2		2			2		2	2	2
	CO4	3	1	3	3	2	2			2		2	3	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS403	ADVANCED SPECTROSCOPY AND APPLICATIONS IN STRUCTURAL ANALYSIS	SC	2	0	0	2	2

Course Objectives:

The practical course on Analytical chemistry intends to provide the students to,

i. Acquire knowledge about the widely used analytical Instruments
ii. Provide experience in some scientific methods employed in analytical chemistry.
iii. Understand the chemical methods employed for elemental and compound analysis.
iv. This course provides students to analyse the compounds using spectroscopic data of UV-Vis spectra, IR, NMR, EPR, XRD, MASS etc.

Course Out comes:

On successful completion of the practical course students shall be able to:

CO1. Understand the working principle, theory and application of various instrumental method.

CO2. Acquire the analytical skills on various analytical instrumental techniques used to identify and solve the problem.

CO3. Interpret the chemical composition and structure of the compound using spectral data.

CO4. Design an analytical work-flow to acquire data and achieve the research objectives of their project.

Course Content:

UNIT-I: Powder Diffraction Methods and calibration techniques: The modern Automated diffractometer, Applications of the Powder Method, Qualitative phase analysis, Crystallography and space group analysis, Indexing and lattice parameter determination, refinement and identification, Powder pattern calculation, Crystal structure determination -The Rietveld method.

Single Crystal Methods: Quantitative X-ray Diffraction, Interaction of X-rays with matter, absorption and EXAFS (time?), X-ray reflectometry analysis, Small Angle scattering, Patterson Function, Pair correlation functions and linkage to structure function, Application to spherical, elliptical and needle shape inclusions.

[10 hrs]

UNIT-II: Particle size measurement: Basic principle of particle analysis, equivalent sphere model, D[1,0], D[3,2] and D[4,3] representations, conversion between length and volume/mass means, mean, median and mode statistics; Methods of measurement of particle size, XRD, optical and laser scattering

techniques; surface area and porosity; definition and meaning, measurement using BET method , adsorption isotherms, DC polarization, AC impedance measurements. **[10 hrs]**

UNIT – III: EPR: hyperfine splitting in various systems, factors affecting the magnitude of g-value, Anisotropy in the hyperfine coupling constants, zero-field splitting and Kramers' degeneracy, nuclear quadrupole interactions. Applications.

NQR: Basic theory, effect of magnetic field in the spectra, relationship between 'q' and molecular structure. Structural information from NQR spectra, Applications.

Mossbauer: Gamma ray emission and absorption by nuclei, Mossbauer effect-conditions, nuclear recoil, Doppler effect, instrumentation, chemical shift examples, quadrupole effect, effect of magnetic field, effect of simultaneous electric and magnetic fields, Use of Mossbauer spectra in chemical analysis, typical spectra of iron and tin compounds. **[10 hrs]**

UNIT-IV:Spectral analysis: Application of combined spectroscopic techniques in structural analysis of organic and inorganic compounds using UV-Vis, FTIR, NMR (^{1}H-NMR, C-13 NMR, F-19 NMR, P-31 NMR), MASS, ESR, NQR, Mossbauer spectroscopic techniques. **[10 hrs]**

References:

1. Elements of Modern X-ray Physics, 2nd Edition, Jens Als-Nielsen and Des Mc Morrow, Wiley & Sons (2011).
2. Modern Powder, Diffraction Reviews in Mineralogy, D. L. Bish and J. E. Post Vol. 20, Mineralogical Society of America, (1989).
3. Fundamentals of Analytical Chemistry. 7th Edition, D. A. Skoog, D. M. West and F. J. Holler, Saunders College Publishing (1996).
4. Instrumental methods of Analysis. H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Set, CBS Publishers (1996).
5. Introduction to Spectroscopy, 4th Edition, Donald L. Pavia.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21SM S403	CO1	3	2	1	1	1	2	3	2	2	2	2		2
	CO2	1	2	1	1	3	2	2	2	2	2	2		2
	CO3	2	2		1	2	2	2	1	2	2	2		2
	CO4	1	2	1		2	2	2	2	2	1	1		2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS404	ADVANCED ELECTROANALYTICAL TECHNIQUES	DSEC/SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Knowledge on Electrode types, electrochemical characterization techniques, Electrochemical STM, Electrochemical AFM, Sensors.

ii. Skilled in problem solving, critical thinking and Analytical reasoning as applied to scientific Problems

iii. Conclude Fundamental Concepts in Analytical Electrochemistry- Mass transport, Linear diffusion, Fick's laws and diffusion coefficient.

iv. Design and carryout scientific experiments as well as accurately record and analyze the results of such experiments

Course Outcomes:

By the completion of course student will be able to

CO5. Acquire the knowledge Mass transport, Linear diffusion, Fick's laws and diffusion coefficient, the charged interface, Potential step and potential sweep experiments.

CO6. Analyze the compounds by using the analytical techniques.

CO7. Explain the Advanced analytical techniques (Sensors) which are useful to analyse the compounds.

CO8. Students will be able to function as a member of an interdisciplinary problem solving.

Course Content:

UNIT- I

Fundamental Concepts in Analytical Electrochemistry: Mass transport, Linear diffusion, Fick's laws and diffusion coefficient, The charged interface, Potential step and potential sweep experiments, Reactions controlled by rate of electron transfer and activated complex theory and Electrode reactions.

[8 hrs]

UNIT -II

Electrode types, Electrochemical characterization techniques – Cyclic voltammetry, Potentiostatic and galvanostatic methods, Pulse methods, RRDE, impedance analysis. **[7 hrs]**

UNIT -III

Photoelectrochemical measurements, I-V measurements, IPCE, Efficiency, Spectroelectrochemistry, Electrochemical STM, Electrochemical AFM. **[8 hrs]**

UNIT -IV

Electrochemical sensing, Electrochemical biosensors, Electron transfer in DNA and biosystems, Photoelectrochemical sensing. **[7 hrs]**

References:

1. Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Allen J. Bard, Larry R. Faulkner, John Wiley & Sons, (2001).
2. Electroanalytical Chemistry, Vol.13, Plenum Press Allen J. Bard (Ed) (1983).
3. Analytical Electrochemistry, 3rd Edition, Joseph Wang, John Wiley & Sons, (2006).
4. Electrochemical Systems, 3rd Edition, J. Newman, Wiley-Inter science, (2004).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS404	CO1	3	1		3	2		2	2		2	2	2	1
	CO2	2	2	2	3	3		1	2	2	3		2	2
	CO3	3	2	2	2	2	1	2	2	2	2	1	1	2
	CO4	2	3	2	1	2	2	2	2	2	3	2	1	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS405	ADVANCES IN SURFACE, INTERFACE AND CATALYSIS	DSEC/SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

i. Intends to enlighten the students in Suface forces, surface energy, Electrostatic forces, Electrical double layer, Solid surfaces, structures, Thermodynamics of Adsorption processes.

ii. This course provides students to get knowledge on Fundamental processes in catalysis, Structures, Kinetic aspects Heterogenous catalysts, Synthesis of metal oxide catalysts, catalysis by porous materials.

iii. Students are able to understand the fundamental of metal oxide and catalysis.

iv. Build research knowledge on photocatalysis, electrocatalysis, devices and their application.

Course Outcomes:

By the completion of course student will be able to

CO1. Acquire the knowledge of suface forces, surface energy, Electrostatic forces, Electrical double layer, Solid surfaces and structures.

CO2. Explain the Fundamental processes in catalysis, Structures, Kinetic aspects Heterogenous catalysts, Bio enzyme catalysis.

CO3. Synthesize the metal oxide catalysts, catalysis by porous materials.

CO4. Identify the Photocatalysts, Electro catalysts.

Course Content:

UNIT - I

Sufaces: Suface forces, surface energy, Electrostatic forces, Electrical double layer, Solid surfaces, structures, Thermodynamics of Adsorption processes, Colloidal systems, stability, -coagulation, charged colloids, thin liquid films, emulsions Application of colloids. **[8 hrs]**

UNIT- II

Interface: Solid-liquid interface, Liquid-liquid interface, Surface analysis – scanning probe microscopy, EELS, BET- Surface area analysis, Microscopic analysis, Thermal analysis. **[7 hrs]**

UNIT -III

Catalysis: Fundamental processes in catalysis, Structures, Kinetic aspects Heterogenous catalysts, Synthesis of metal oxide catalysts, catalysis by porous materials. **[7 hrs]**

UNIT IV

Catalysis for sustainable energy: Photocatalysts, Electrocatalysts, device application, Catalysis in industrial processes, Bio enzyme catalysis. **[8 hrs]**

References:

1. Physical chemistry of surfaces, Arthur W. Adamson (1990).
2. Surface Science: Foundations of Catalysis and Nanoscience, K.W. Kolasinski, Wiley, (2002).
3. Modern techniques of surface science, D.P. Woodruff, T. A. Delchar, Cambridge Univ. Press, (1994).
4. Principles and Practice of Heterogeneous Catalysis, M. Thomas, W.J. Thomas, Wiley-VCH, (1997).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS405	CO1	3	3	1		2	1				2	2	4	3
	CO2	4	3	3	2	3	3			1	2	3	4	2
	CO3	2	1	3	3	3	2			1	2	3	4	3
	CO4	1	3	3	2	3	3			1	2	2	4	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS406	ADVANCED MATERIALS IN ENERGY STORAGE AND CONVERSION DEVICES	SC	2	0	0	2	2

Course Objectives:

This course aims to provide the student to

1. Intends to enlighten the students in charge transfer process, electrochemical energy conversion device processes.
2. This course provides students to get knowledge Electro catalysis in fuel cells, semiconducting materials.

Course Outcomes:

By the completion of course student will be able to

1. Acquire the knowledge of charge transfer processes, electrochemical energy conversion device processes in the cells.
2. Construct the different types of Batteries.
3. Identify the Electrode and Electrolyte materials used in the different batteries.
4. Explain the solar cells, water splitting and photo electrochemical cells.

Course Content:

UNIT- I

Electrochemistry: fundamental processes, charge transfer process, Electrochemical energy conversion device processes, Fundamental thermodynamic and kinetic consideration, Available energy resources, Ragone plot. **[8 hrs]**

UNIT -II

Different battery systems Electrode materials for Lithium-ion batteries, Sodium ion batteries, Li-S batteries, Cathode materials, anode materials, high power supercapacitors. **[7 hrs]**

UNIT -III

Electrocatalysis in fuel cells, HOR, ORR Noble metals, non-noble metal and other electrocatalysic systems, Different types of fuel cells, acid, alkaline, molten carbonate, solid oxide fuel cells solid polymer electrolyte, methanol, biochemical fuel cells and Photoelectrocatalysis. **[8 hrs]**

UNIT -IV

Fundamentals of semiconducting materials – solar energy conversion, Photoelectrochemical cells, Organoelectronics, Hydrogen a clean fuel, water splitting and photoelectrochemical cells hydrogen storage materials. **[7 hrs]**

References:

1. Chemical and Electrochemical energy systems, R. Narayanan and B. Viswanathan, Orient Longmans, (1997).
2. Basic Nuclear Engineering, K. Sriram, Wiley Eastern, (1990).
3. Fuel Cell Hand Book, A. S. J. Appleby, F. K. Foulkes, Von Nostrand Reinhold, (1989).
4. Hand book of batteries and Fuel cells, D. Linden, McGraw Hill Book Company, (1984).
5. Solar Hydrogen energy systems, T. Ohta, Peragamon Press, (1979).
6. Energy Resources through photochemistry and catalysis, M. Gratzel, Academic Press, (1983).
7. Energy Technology, Sources, Systems and Frontiers conversions, T. Ohta, Pergamon, (1994).
8. Electrochemistry, Bockris and Reddy.

Mapping of Course Outcomes with programme Outcomes

Course Code	**POS/ Cos**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PS O1**	**PS O2**	**PS O3**
M21S MS406	CO1	3	2	2	2	1	3	2	1	2	1	3	2	2
	CO2	2	2	3	2	2	2	2	2	2	2	3	3	2
	CO3	2	3	2	3	3	1	2	2	2	2	2	2	3
	CO4	3	1	1	2	2	2	2	2	3	3	2	3	2

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS407	ADVANCES IN POLYMER SCIENCE AND TECHNOLOGY	SC	2	1	0	3	4

Course objectives:

This course aims to provide the student to

i. Demonstrate the knowledge of the basic concept of polymer, analysis of molecular weight of polymer.

ii. Explore physical factors of polymers, analysis of glass transition temperature of polymer, Thermodynamic equation of polymer.

iii. Create broad knowledge on polymer classification, mechanism of polymerization, instrumentation method of polymer characterization.

iv. Acquire broad knowledge of polymers for medical, environmental, catalysis and device applications.

Course Outcomes:

By the completion of course student will be able to

CO1. Basic of polymer, analysis.

CO2. Physical factors, analysis, equations.

CO3. Classification, mechanism, techniques.

CO4. Applications, environmental.

Course Content:

UNIT- I

Introduction to polymer science, Molecular weights and Methods of determination, molecular weight distribution, size and shape of macromolecules, Mark-Houwink relationship, chain structure and configuration, conformation, size of an ideal chain (freely jointed chain and other models), Real chains, Thermodynamics of polymer solutions; Molecular motion (self-diffusion, hydrodynamic radius, Rouse Model).Glass transition temperature – elementary theories and methods of determination. Variation of glass transition with structure. **[8 hrs]**

UNIT -II

Membrane technology for separation: Basic principle, Types of membranes/classification, synthesis of membrane; polymer membranes, structural analysis, factors affecting membrane separation, comprehensive applications. Ionically conducting membranes and Applications. **[7 hrs]**

UNIT -III

Polymer characterisation: Transport mechanism in membranes, characterisation of ionic membranes, porous and nonporous systems, Microscopic techniques, Gas adsorption-desorption, Thermoporemetry Inorganic membranes: Introduction, types, membrane synthesis, glass membranes and Applications.

[8 hrs]

UNIT- IV

Applications of Polymers: Conducting polymers, Organic Photovoltaics, polymer electronics energy conversion devices, Corrosion protection, Thermal resistant polymers, catalysis, Metallopolymers, Biocompatible polymers, Biodegradable polymers. **[7 hrs]**

References:

1. Textbook of Polymer Science, 3rdEdition, F. W. Billmeyer, John Wiley, 1994.
2. Polymer Science, V. R. Gowariker, N. V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd, (2005).
3. Principles of Polymerization, 4th Edition, G. Odian, Wiley-Interscience, (2004).
4. Basic principles of Membrane technology, Marcel Mulder, Springer, (1996).

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS407	CO1	2	1		2	1						2	2	1
	CO2	2			2	1						2	2	1
	CO3	2	1		1	1						2	2	1
	CO4	2		2			1					2	2	1

SEMESTER-IV

MOOC/SWAYAM/HARVARD/Edx/INTERNSHIP

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SMON41	MOOC/SWAYAM/HARVARD/EDX/ INTERNSHIP/ATTENDING CONFERENCES/WEBINARS/INDUSTRIAL VISIT/ IN-HOUSE R&D, ETC. (ALL SEMESTER)	RULO	4	0	0	4	4

Course Objectives:

To carry out the research or internship at Industry/R&D Institution and in the process learn the techniques of research or Self learning related courses from MOOC/SWAYAM/HARVARD/Edx.

Course Outcomes:

By the completion of course student will be able to

CO1. Familiarize with R&D culture.

CO2. Conduct the experiments related to research and formulate computational techniques

CO3. Interpret the scientific data and Write report and defend the research findings.

CO4. Apply the self-learning capabilities

Internship: Minimum of four weeks duration internship should be carried out by the student either in industry or in an R&D organization, including educational institutes with excellent research culture. In case, if a student is unable to secure internship either in industry or in an R&D organization, a project may be carried out within the university. The student is expected to submit a formal report at the end of the internship programme. The student shall be awarded the marks for internship based on the (a) presentation and (b) comprehensive viva by the panel of examiners constituted by the school.

MOOC/ SWAYAM: Globally, MOOC (Massive Open Online Course) platforms are gaining much popularity. Considering the popularity and relevance of MOOCs, Government of India has also launched an indigenous platform, SWAYAM. SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) is basically an integrated MOOCs platform for distance education that is aimed at offering all the courses from school level (Class IX) to post-graduation level. The platform has been developed collaboratively by MHRD (Ministry of Human Resource Development) and AICTE (All India Council for Technical Education) with the help of Microsoft and is capable of hosting 2,000 courses.

A student shall register and successfully complete any of the courses available on SWAYAM.

Student shall inform the MOOC/SWAYAM coordinator of the school about the course to which he/she has enrolled. The minimum duration of the course shall be not less than 40 hours and of 4 credits. The student should submit the certificate issued by the SWAYAM to the MOOC/SWAYAM coordinator of the school, the grades obtained in the course shall be forwarded to concerned authority of the University.

SEMESTER IV – ADVANCED ORGANIC CHEMISTRY PRACTICALS

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS408	ADVANCED ORGANIC CHEMISTRY LAB-IV.1	SC	0	0	3	3	5

Course Objectives:

This course on ADVANCED ORGANIC CHEMISTRY LAB provides students to enlighten the knowledge on topics like

i. Synthesis, separation, purification, characterization and property measurements of Organic compounds with an emphasis on different techniques of reaction set-up.
ii. Exposure to various spectroscopic characterization techniques.
iii. Formulate the scheme for an organic chemical reaction and record the systematic procedure.
iv. Analyze the spectral data to obtain the structure of the organic compound.

Course Outcomes:

By the completion of course student will be able to,

CO1. Apply the knowledge on Synthesis, separation, purification, characterization.
CO2. Acquire knowledge on various spectroscopic characterization techniques.
CO3. Design and research problems in organic synthesis.
CO4. Solve the analytical data obtained and interpret the structure of the organic compound.

.

Course Description:

1. Synthesis, separation, purification, characterization and property measurements of Organic compounds with an emphasis on different techniques of reaction set-up.
2. Exposure to various spectroscopic characterization techniques.
3. Carryout protection and deprotection reactions for the functional groups-NH_2, -COOH, -OH etc.,
4. Independently carry out the synthesis of amide bonds using different coupling agents-DCC, EDC, HATU, HOBT etc, purify the organic compounds through column chromatographic techniques and characterize the final amide derivatives.

References:

1. Vogel's Textbook of Practical Organic Chemistry, 5th Edition,Brian S. Furniss, Antony J. Hannaford, Peter W. G. Smith, Austin R. Tatchell, Longman Scientific and Technical, (1989).
2. Some modern methods of Organic Synthesis, 2nd Edition.W. Caruthers, Cambridge University. Press London, (1998).
3. Organic synthesis: Special Techniques, K. Ahluwalia and R. Aggarwal, Narosa, New Delhi, (2003).
4. Spectrometric Identification of Organic Compounds, R.M. Silverstein and W.P. Webster, Wiley & Sons, (1999).
5. Introduction to Spectroscopy, 3rd Edition, Pavia, Lampman and Kriz, Thomson.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS408	CO1	3	2	2	2	2	2		1	1	1	3	3	3
	CO2	3	2		3	2	1				1	3	3	2
	CO3	3	3	3	2	3	1			1	1	3	2	2
	CO4	3	2		2	2	2			1	1	3	3	3

SEMESTER IV – ADVANCED INORGANIC CHEMISTRY PRACTICALS

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS409	ADVANCED INORGANIC CHEMISTRY LAB-IV.2	SC	0	0	3	3	5

Course Objectives:

This course aims to provide the student to

i. Synthesis, characterization and property measurements of inorganic compounds with an emphasis on different techniques of reaction set-up, conducting polymers.
ii. Exposure to various spectroscopic characterization techniques.
iii. To use electroanalytical techniques in synthesis and characterization.
iv. To analyse coordination complexes and conducting polymers and metal oxides.

Course Outcomes:

By the completion of course student will be able to

CO1. Apply the experimental knowledge to synthesis new compounds by environmental benign routes and interpret their properties

CO2. Devise the methodology in synthesis and optimize the condition for preparation new experiments

CO3. Analyze the spectral data and evaluate the electronic properties and bond vibrations and bond strengths

CO4. Interpret the data obtained through various electrochemical and solution synthesis techniques of chemical compounds and their characterization

Course contents:

Part-I: Preparation of nanostructured materials by chemical and electrochemical methods

1. Preparation of MnO_2 by ethylene glycol as a reducing agent.
2. In-situ preparation of polyaniline-MnO_2 composites.
3. In-situ preparation of Polypyrrole-MnO_2 composites.
1. Preparation of Ag nano particles using $NaBH_4$ and their spectral studies.
2. Electrochemical synthesis of Manganese dioxide films.
3. Preparation of polyaniline thin films by electropolymerization of aniline.
4. Preparation of polypyrrole thin films by electropolymerization of pyrrole.
5. Electrodeposition of zinc, nickel, copper and verification of Faradays's law.
6. Electrochemical anodization of copper and zinc.

Part-II: Chemical, Electrochemical and spectral analysis

1. Preparation of Ag/AgCl reference electrode.
2. Redox behaviour of potassium ferricyanide, cobalt complexes using cyclic voltametry technique.
3. Construction and Supercapacitor behaviour of electrical double layer capacitor and Pseudocapacitor.
4. Construction and super capacitor studies of Hybrid electrode material (metal oxide-polymer).
5. Estimation of Chloride ions in copper ammonium complex.
6. Estimation of Chloride ions in cobalt ammonium complex.
7. Spectral studies of metal complexes and their CFSE interpretation.
8. Cu, Ni, and Co ammonium complexes: ligand displacement reaction with different concentration of ammonia monitored by UV-VIS spectra.

References:

1. Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Allen J. Bard, Larry R. Faulkner.
2. Energy Resources through photochemistry and catalysis, M. Gratzel, Academic Press, (1983).
3. T. Ohta, Energy Technology, Sources, Systems and Frontiers conversions, Pergamon, (1994).
4. Electrochemistry, Bockris, Reddy.
5. Standard Potentials in Aqueous Solution, Allen J. Bard, Larry R. Faulkner.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS409	CO1	2	1	2	2	2	1			1	1	2	2	2
	CO2	2	1	1	2	2	1			1	2	2	1	3
	CO3	2	1	2	2	2	1			2	2	2	2	2
	CO4	3	1	2	2	2	2			1	2	3	2	3

SEMESTER IV – ANALYTICAL CHEMISTRY PRACTICALS

Course Code	Course Title	Type	L	T	P	C	Hrs/Week
M21SMS411	ANALYTICAL CHEMISTRY LAB-IV.3	SC	0	0	3	3	5

Course Objectives:

The practical course on Analytical chemistry intends to provide the students to,

i. Learn different electro analytical techniques for sample analysis.
ii. Impart training in practical experience in selected instrumental methods of analysis.
iii. Able to synthesize materials, characterization and chemical analysis.
iv. Understanding the theoretical principles and practical applications of different chromatographic techniques.

Course Outcomes:

By the completion of course student will be able to

CO1. Interpret the results of quantitative experiments and interpret the data in meaningful ways.

CO2. Analyze the chemical methods employed for compound analysis.

CO3. Illustrate the experimental skills on different instrumental analysis of the given compounds.

CO4. Discuss the fundamentals, critical thinking and analytical reasoning as applied to scientific problems.

Course contents:

1. Determination of fluoride in drinking water by Spectrophotometry (Zr-Alizarin method).
2. Estimation of caffeine in a given sample using UV Spectrophotometer.
3. Spectrophotometric determination of pKa value of an indicator (the acid dissociation constant of methyl red).
4. Separation and identification of metal ions in a mixture by paper chromatography/TLC.
5. Synthesis of metal oxides and their characterization by XRD technique.
6. Preparation of Hexamine Nickel (II) chloride complex and its characterization by IR Spectroscopy.
7. Investigate the autocatalytic activity between potassium permanganate and oxalic acid.
8. Spectral analysis of alcohols and amines by NMR Spectroscopy.
9. To determine the percentage of ascorbic acid in a given sample using HPLC.
10. Titrate potentiometrically Zn (II) by Potassium Ferrocynanide and verify the composition of the complex.

References:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, Third Indian Reprint, Pearson Education Pvt. Ltd., New Delhi, (2003).
2. Analytical Chemistry: An introduction Skoog, West, Holler and Crouch; 7th edition Saunders College Publishing (1999).
3. Chromatography, C. G. Sharma.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3
M21S MS411	CO1	2	3	3	3	3	3	3	3	1	2	2	3	3
	CO2	2	3	3	3	2	2	3	1	2	2	2	3	3
	CO3	2	2	2	2	3	3	2	2	1	1	2	3	3
	CO4	3	3	3	3	2	2	1	2	1	3	2	3	3

INORGANIC CHEMISTRY

Course Outcomes:

1. During the study of this course the students will acquire a deeper knowledge about basics in inorganic chemistry periodic properties, solvents, nuclear chemistry etc.
2. After studying this subject student is able to understand how nanomaterials are completely different from that of bulk materials, its approaches for synthesis and its applications.
3. During the study of this course the students will acquire a deeper knowledge complexes, metal ligand interactions about chemistry.
4. Student is able to understand various principles of bioinorganic chemistry, Bioenergetics, biophysical chemistry, bioorganic chemistry etc.
5. The students are expected to acquire knowledge about inorganic reaction mechanisms and organometallic chemistry.
6. After the completion student is able to understand about energy for chemical industry, surfactants, explosives, pesticides their effect to the environment. Importance of industrial materials like cement, polymers, glass, paint, fertilizes etc can be understood here.
7. Student is able to understand different types of solids, its reactions, electronic properties and band theory and gets an information regarding advanced electronic materials.
8. Student will be familiar with various spectroscopies like electron spectroscopy, Mossbauer spectroscopy, destructive techniques and non-destructive techniques, SAM, SPM, TEM, LEED etc.
9. Students will understand the principles in inorganic photochemistry, metal complexes in drugs, medicinal bioinorganic chemistry and advance nuclear chemistry.

ORGANIC CHEMISTRY

Course Outcomes:

The students will acquire knowledge of:

1. The structure, nature of bonding in the molecules and reaction mechanism.
2. Conformational analysis of cycloalkanes, reactivity, chirality, interconversion, resolution and asymmetric synthesis.
3. Organization and working of various components present in living cell.
4. Nomenclature of different heterocyclic compounds.
5. Synthesis and reactivity five, six and seven membered monocycles and the fused heterocyclic compounds.
6. Molecular structure of proteins, DNA, RNA and vitamins, organization and working of various components present in living cell.

7. Mechanistic aspects of nucleophilic, electrophilic substitution and elimination reactions.
8. Molecular orbital symmetry and possibility of thermally and photochemically pericyclic reactions.
9. Conversion of different functional groups via rearrangement reactions.
10. Molecular recognition and nature of binding involved in biological systems.
11. Structure of supramolecules of various types in solution, solids and their applications in miniaturization of molecular devices.
12. Drug designing, development, mode of action of different drugs and role of drugs to inhibit particular enzymes and treatment of disease.
13. Mechanistic pathway of organic reactions.
14. Retrosynthetic approach of planning organic synthesis
15. Conversion of different functional groups via reactions.
16. Mechanism of major chemical reactions.
17. Utilizing reagents in organic transformations.
18. The principles behind Enantio-selectivity and Diastero-selectivity, analyze how stereochemical outcome of the reaction can be predicted.
19. Identifying and characterizing various classes of natural products by their structure.
20. Appreciate the biogenesis of many natural products of importance.
21. The contribution of natural products in drug design and development of new drugs with hemisynthetic routes or with total synthesis.

PHYSICAL CHEMISTRY

Course Outcomes:

After completion, of course students will:

1. Acquire knowledge about basics of thermodynamics, chemical kinetics and electrochemistry.
2. Understand the Thermodynamic laws, concepts of entropy and free energy, partial molar properties, fugacity of gases, thermodynamics of dilute solutions, statistical thermodynamics.
3. Get knowledge on kinetics of complex reactions, Parallel, consecutive and reversible reactions.
4. Acquire knowledge on theories of electrolytes and irreversible electrode processes, cyclic voltammetry, Impedance Spectroscopy, Scanning Electrochemical Microscopy, Electrochemical AFM and STM, electrochemical sensors and energy systems.
5. Able to analyze the kinetics of the different types of reactions
6. Understand Surface phenomena of solids, solid-liquid interfaces, Homogenous and Heterogeneous Catalysis.
7. Analyze the instrumental methods of catalyst characterization.

8. Enlighten the knowledge on Quantum chemistry, molecular symmetry, group theory: representation and applications, various spectroscopic techniques like microwave, vibrational, electronic, Raman, EPR and NMR.
9. Understand the principles and laws of photochemistry, measurement of fluorescence and phosphorescence and lifetimes and Fluorescence based sensors.
10. Get knowledge on topics like energy systems: renewable and non-renewable, nuclear energy, electro chemical power sources, chemistry of fuel cells and semi conducting materials.
11. Understand topics like quantum chemistry, Statistical Thermodynamics and non-equilibrium thermodynamics, molecular interactions and macro molecules.
12. Understand topics like quantum chemistry, Statistical Thermodynamics and non-equilibrium thermodynamics, molecular interactions and macro molecules.
13. Understand basic concepts of polymers, thermodynamics of polymer solutions, classification, structure-property relation of polymers and different applications of polymers.

ANALYTICAL CHEMISTRY

Course Outcomes:

After completion, of course students will:

1. Acquire knowledge of Data handling/ statistical treatment of data.
2. Acquire knowledge of Potentiometric, Coulometric, and Voltametric methods of analysis, Chromatographic Techniques and applications.
3. Identify and describe the steps that are included in a complete analytical procedure
4. Learn the basic analytical and technical skills to work effectively in the various fields of chemistry.
5. To know and understand the issues of safety regulations in the use of chemicals in their laboratory work.
6. Students can define and calculate theretention factor, R f, and describe how TLC and column chromatography can be used for separation and qualitative analysis.
7. This study is useful to furnish students with the advanced technical skills and knowledge base
8. That is required in the field of instrumental analysis and which will enable them to pursue ca-reers as analysts in the chemical and/or pharmaceutical industry.
9. The fundamental analytical techniques, Mass spectrometry, NMR spectroscopy and electron spectroscopy.
10. Other general characterisation techniques (IR & UV spectroscopy, mass and NMR spec-troscopy).
11. About spectroscopy and its application in studying the structure of organic molecules.
12. Gain knowledge and understand the principle of Separation techniques, analysis by using spectroscopic techniques.
13. Demonstrate the Chromatographic Techniques and applications.

14. In this practical course the students acquire practical skills related to analytical chemis-try in analysis of constituents present in different samples.
15. The students will acquire knowledge of development of experimental skills on conductivity meter, potentiometer, pH meter and voltammeter for different applications
16. Different concepts of atmosphere, stratospheric and tropospheric chemistry, photochemical smog, acid rain, atmospheric aerosols, global climate.
17. Chemistry of colloids with reference to environment.
18. Air pollution, water pollution, soil pollution and its control.
19. Analysis of various components in food and drug analysis.
20. Concepts and applications of Green Chemistry.
21. Concepts of types of materials, properties of nanomaterials and various preparation methods and characterization techniques like XRD, SEM, TEM, NMR, XPS and applications
22. Concepts of water pollution and water analysis methods.

CAREER DEVELOPMENT AND PLACEMENT

Having a degree will open doors to the world of opportunities for you. But Employers are looking for much more than just a degree. They want graduates who stand out from the crowd and exhibit real life skills that can be applied to their organizations. Examples of such popular skills employers look for include:

1. Willingness to learn
2. Self motivation
3. Team work
4. Communication skills and application of these skills to real scenarios
5. Requirement of gathering, design and analysis, development and testing skills
6. Analytical and Technical skills
7. Computer skills
8. Internet searching skills
9. Information consolidation and presentation skills
10. Role play
11. Group discussion, and so on

REVA University therefore, has given utmost importance to develop these skills through variety of training programs and such other activities that induce the said skills among all students. A full-fledged Career Counseling and Placement division, namely Career Development Center (CDC) headed by well experienced senior Professor and Dean and supported by dynamic trainers, counselors and placement officers and other efficient supportive team does handle all aspects of Internships and placements for the students of REVA University. The prime objective of the CDC is to liaison between REVA graduating students and industries by providing a common platform where the prospective employer companies can identify suitable candidates for placement in their respective organization. The CDC organizes pre-placement training by professionals and also arranges expert talks to our students. It facilitates students to career guidance and improve their employability. In addition, CDC forms teams to perform mock interviews. It makes you to enjoy working with such teams and learn many things apart from working together in a team. It also makes you to participate in various student clubs which helps in developing team culture, variety of job skills and overall personality.

The need of the hour in the field of Chemistry is not only knowledge in the subject, but also the skills to do the job proficiently, team spirit and a flavour of innovation. This kept in focus, the CDC has designed the training process, which will commence from second semester along with the curriculum. Special coaching in personality development, career building, English proficiency, reasoning, puzzles, and communication skills to every student of REVA University is given with utmost care. The process involves continuous training and monitoring the students to develop their soft skills including interpersonal skills that will fetch

them a job of repute in the area of his / her interest and March forward to make better career. The School of Applied Sciences also has emphasised subject based skill training through lab practice, internship, project work, industry interaction and many such skilling techniques. The students during their day to day studies are made to practice these skill techniques as these are inbuilt in the course curriculum. Concerned teachers also continuously guide and monitor the progress of students.

The University has also established University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director to facilitate skill related training to REVA students and other unemployed students around REVA campus. The center conducts variety of skill development programs to students to suite to their career opportunities. Through this skill development centre the students shall compulsorily complete at least two skill / certification based programs before the completion of their degree. The University has collaborations with Industries, Corporate training organizations, research institutions and Government agencies like NSDC (National Skill Development Corporation) to conduct certification programs. REVA University has been recognised as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana.

The University has also signed MOU's with Multi-National Companies, research institutions, and universities abroad to facilitate greater opportunities of employability, students' exchange programs for higher learning and for conducting certification programs.

LIST OF FACULTY MEMBERS

Sl. No	Faculty Name	Designation	Email.Id	Mobile No
1	Dr. Madhusudana Reddy M. B.	Professor &Assistant Director	madhusudana.mb@reva.edu.in	9480224757
2	Dr. Sakthivel Kandaiah	Associate Professor	sakthivel.k@reva.edu.in	9742585588
3	Dr. LakshmiB.	Associate Professor	lakshmib@reva.edu.in	9902632762
4	Dr. Ramakrishna Reddy K.	Associate Professor	k.ramakrishnareddy@reva.edu.in	9885057117
5	Dr. Vipin A.Nair	Associate Professor	vipina.nair@reva.edu.in	9417251206
6	Dr. Nagaraju D. H.	Associate Professor	nagaraju.dh@reva.edu.in	9900634435
7	Dr. Shivakumara S.	Assistant Professor	s.shivakumara@reva.edu.in	9972599779
8	Dr. Nagarajaiah H.	Assistant Professor	nagarajaiah.h@reva.edu.in	9964076373
9	Dr. Nagendra G.	Assistant Professor	nagendra.g@reva.edu.in	9844722805
10	Dr. Sathish Reddy	Assistant Professor	sathish.reddy@reva.edu.in	9353808562
11	Dr. Srinivas M.	Assistant Professor	srinivas.m@reva.edu.in	9900447889
12	Dr. Shivanna M.	Assistant Professor	shivanna.m@reva.edu.in	9964556195
13	Prof. Sreekanth R.	Assistant Professor	sreekanth.r@reva.edu.in	9986769845
14	Prof. Mamatha Mohan	Assistant Professor	mamatha.mohan@reva.edu.in	9980555788
15	Prof. Pushpalatha R.	Assistant Professor	pushpalatha.r@reva.edu.in	8095755650
16	Prof. Shwetha K. R.	Assistant Professor	shwetha.kr@reva.edu.in	9900404059
17	Prof. Mubeena A.	Assistant Professor	mubeen.a@reva.edu.in	8553643347
18	Mr.Chandrashekar P.	Teaching Associate	chandrashekar.p@reva.edu.in	9880206742
19	Mr. Umesh P. V.	Lab Instructor	umesh.pv@reva.edu.in	9742924366