REVA UNIVERSITY
Bengaluru, India

M.Sc. in Chemistry

Scheme of Instructions and Syllabus

Approved

by

RU/BoM/2017-18/01-06-2017

HAND BOOK

2017-2019

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 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 endeavor 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. S. Y. Kulkarni

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 a 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.

Dr. Beena G

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 fulfill 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 DivyaSree 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 11,000 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 27thFebruary, 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.

The University is presently offering 23 Post Graduate Degree programs, 20 Degree and PG Degree programs in various branches of studies and has 12000+ students studying in various branches of knowledge at graduate and post graduate level and 302 Scholars pursuing research leading to PhD in 18 disciplines. It has 800+ well qualified, experienced and committed faculty members of whom majority are doctorates in their respective areas and most of them are guiding students pursuing research leading to PhD.

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, Counselors 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 recognized as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana. 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, Oklahoma 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 facilitate 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 Ratna Prof. 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 Defense Dr. Sathish Reddy, Scientific Advisor, Ministry of Defense, New Delhi and many others have accepted our invitation and blessed our students and faculty members by their inspiring addresses and interaction.

As a part of our effort in motivating and inspiring youth of today, REVA University also has instituted awards and prizes to recognize the services of teachers, researchers, scientists, entrepreneurs, social workers and such others who have contributed richly for the development of the society and progress of the country. One of such awards instituted by REVA University is 'Life Time Achievement Award' to be awarded to successful personalities who have made mark in their field of work. This award is presented on occasion of the "Founders' Day Celebration" of REVA University in presence of dignitaries, faculty members and students gathering and the first "REVA Life Time Achievement Award" for the year 2015 has been awarded to Shri. Kiran Kumar, Chairman ISRO on the occasion of Founder's Day Celebration, 6th January, 2016 and

the second “REVA Life Time Achievement Award” for the year 2016 has been awarded to Shri. Shekhar Gupta, Renowned Journalist on the occasion of Founder’s Day Celebration, 6th January, 2017.

REVA organizes 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 ShubhaVidaaya, - 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 recognized 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 classes every day to students, faculty members, administrative staff and their family members and organizes yoga camps for villagers around.

Recognizing the fast growth of the university and its quality in imparting higher education, the BERG (Business Excellence and Research Group), Singapore has awarded BERG Education Award 2015 to REVA University under Private Universities category. The University has also been honored with many more such honors and recognitions.

About the Department of Chemistry

The school of Chemical Sciences and Biological Sciences headed by a highly experienced professor and is supported by a highly experienced and well qualified faculty member. 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 will develop a learning community of critical thinkers who serves as models of innovative problems solving in the university environment to enrich their professional careers. M.Sc., in Mathematics is designed to meet the present-day demand for specific mathematical and computational skills and training requirements of science, engineering, and technology graduates. The courses are tailored to prepare students in teaching and research as well as in community activities and development. The courses provide opportunity for the students to know about the applications of mathematics in several fields of practical interest including those of designing & writing codes and computer algorithms for dealing with various systems. The areas of study cover analysis, algebra, topology, complex analysis, differential equations, mechanics, discrete mathematics, programming & data structures, design & analysis of algorithms, theory of computation, and numerical techniques. Besides, greater emphasis is laid on methods of Mathematics, fluid mechanics, mathematical modeling and simulation, graph theory, fuzzy logic, cryptography, operations research, and mathematics of multimedia.

The minor project work that the students must undertake compulsorily is integrated with industry experience. This will not only enhance acquaintance to applications of mathematics, computation and their models to real world problems but improve students' knowledge and self-confidence. The school also has research program leading to doctoral degree. The curriculum of both graduate and post-graduate degree programs has been designed to bridge the gap between academia-research. The program focusses on research to offer professional services at National and International levels

Following are the vision, mission, program educational objectives and program outcomes.

VISION STATEMENT OF UNIVERSITY

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.

VISION STATEMENT OF SCHOOL

To achieve excellence in the field of Chemical Sciences through academic and research programmes and to participate in the interdisciplinary programmes offered in the University.

MISSION STATEMENT OF SCHOOL

- To provide knowledge and skill in Chemical Sciences through post graduate and doctoral programmes.
- To undertake research in emerging areas of Chemical Sciences and transform the findings for the benefit of the society.
- To establish collaboration with industries and research Institutes to promote joint research projects.
- To provide required knowledge in Chemical Sciences for all programs in science and engineering.

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,

The Program Educational objectives are to prepare the students to:

1. Work as a scientist or faculty in educational institutions and research organizations in a team with further training.
2. Develop strong ethics and communication as consultant with lifelong learning attitude.
3. Pursue higher studies to address the problems of the society.

Program Outcomes (POs)

After undergoing this programme, a student will be able to:

1. **Knowledge Sharing:** Apply the knowledge of fundamentals mathematics, physics and advanced chemistry to resolve the problems in everyday life.
2. **Problem analysis:** Analysis of research problems and chemical compounds and provide solutions at national and international level.

3. **Design/development of solutions:** Design and develop the eco-friendly products required for the present and future generation.
4. **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.
5. **Research skills:** Enhance the research skills and carryout the extensive research literature in advanced chemical studies.
6. **Environment and sustainability:** Apply critical thinking ability to achieve sustainable solutions for energy and environment.
7. **Ethics:** Apply ethical principles and commit to ethics, and responsibilities and norms of the professional practice
8. **Individual and team work:** Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
9. **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.
10. **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.

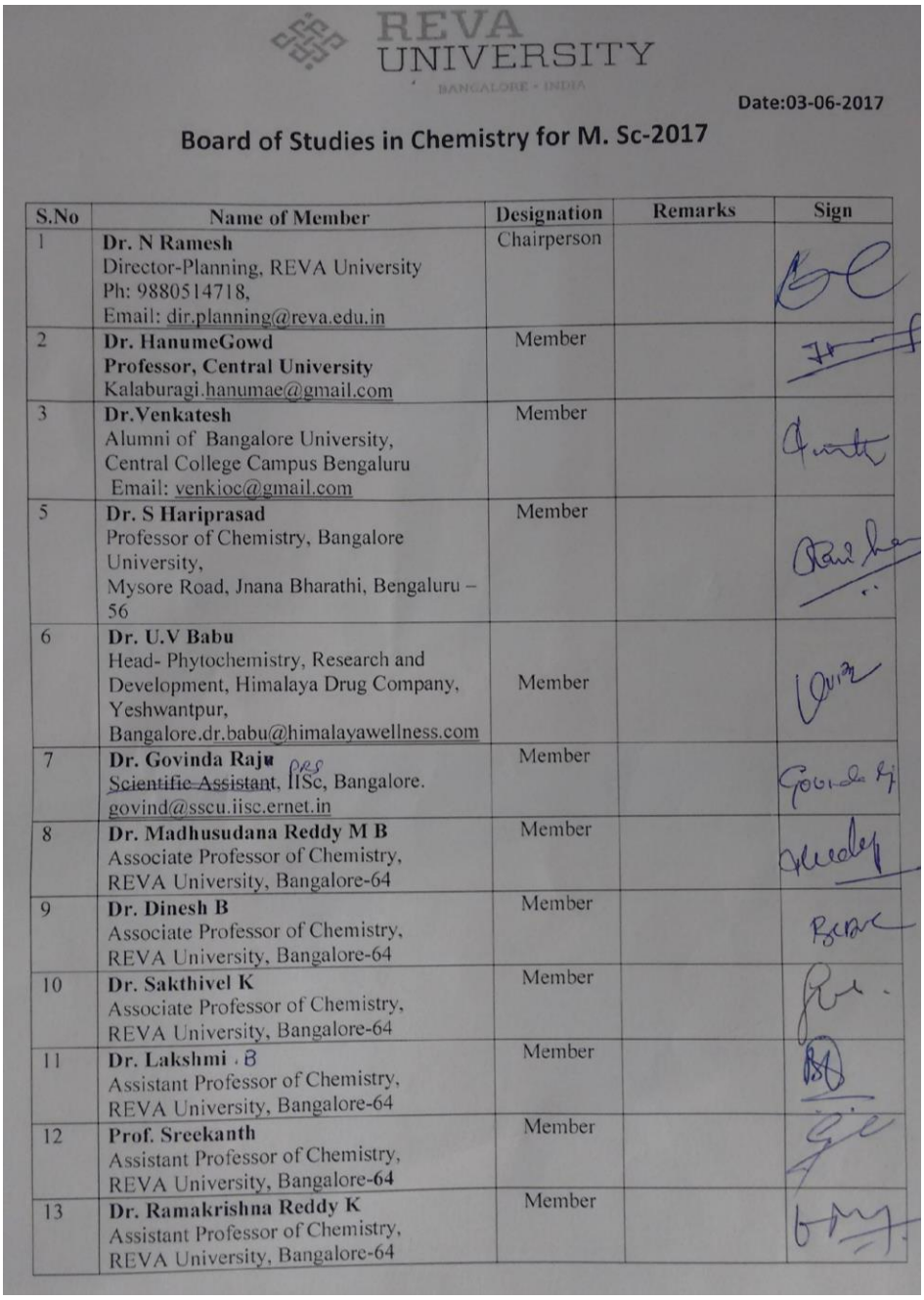
Program Specific Outcomes (PSOs)

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

1. Apply the various concepts of organic, inorganic, analytical, physical chemistry aspects and their applications in day to day life.
2. Apply various analytical techniques such as XRD, UV, IR, NMR, Mass, Chromatography for chemical analysis.
3. Use modern techniques and tools for research and development and provide solutions in the field of chemical sciences.

Advisory Board

Proceedings of the meeting of the Board of Studies in M. Sc chemistry held on 03.06.2017 at 2.30PM to 4.45 PM in the Department of Chemistry, REVA University, Kattigenahalli, Yelahanka, Bangalore.



REVA UNIVERSITY
BANGALORE - INDIA

Date:03-06-2017

Board of Studies in Chemistry for M. Sc-2017

S.No	Name of Member	Designation	Remarks	Sign
1	**Dr. N Ramesh** Director-Planning, REVA University Ph: 9880514718, Email: dir.planning@reva.edu.in	Chairperson		
2	**Dr. HanumeGowd** **Professor, Central University** Kalaburagi.hanumae@gmail.com	Member		
3	**Dr.Venkatesh** Alumni of Bangalore University, Central College Campus Bengaluru Email: venkioc@gmail.com	Member		
5	**Dr. S Hariprasad** Professor of Chemistry, Bangalore University, Mysore Road, Jnana Bharathi, Bengaluru – 56	Member		
6	**Dr. U.V Babu** Head- Phytochemistry, Research and Development, Himalaya Drug Company, Yeshwantpur, Bangalore.dr.babu@himalayawellness.com	Member		
7	**Dr. Govinda Raju** ~~Scientific Assistant~~, IISc, Bangalore. govind@sscu.iisc.ernet.in	Member		
8	**Dr. Madhusudana Reddy M B** Associate Professor of Chemistry, REVA University, Bangalore-64	Member		
9	**Dr. Dinesh B** Associate Professor of Chemistry, REVA University, Bangalore-64	Member		
10	**Dr. Sakthivel K** Associate Professor of Chemistry, REVA University, Bangalore-64	Member		
11	**Dr. Lakshmi . B** Assistant Professor of Chemistry, REVA University, Bangalore-64	Member		
12	**Prof. Sreekanth** Assistant Professor of Chemistry, REVA University, Bangalore-64	Member		
13	**Dr. Ramakrishna Reddy K** Assistant Professor of Chemistry, REVA University, Bangalore-64	Member		

Proceedings

At the outset, the Dr. N. Ramesh, Chairperson of the BOS in Chemistry welcomed all the members present, explained the purpose of the meeting and the agenda in brief. Then the agenda was taken up for discussion. The adviser of REVA University Dr. V. G. Talwar also addressed to the members of BOS.

Agenda 1:

Preparation of Course Curriculum

The Chairperson explained briefly about the establishment of REVA University and the course(s) being introduced under REVA University. He also explained the features of CBCS/CAGP of education the University is committed to follow since its inception itself. He requested all the members to corporate and to draft the curriculum as per the REVA University Regulations for CBCS-CAGP for PG programs/ Diploma programs.

The BOS members discussed the agenda in detail and drafted the course curriculum including the scheme of instruction, eligibility criterion, etc. The Board also drafted detailed syllabus.

Resolution:

The Board unanimously resolved to adopt CBCS-CAGP of education for M. Sc Chemistry program from the Academic Year 2017-18 and recommend the University to adopt detailed curriculum drafted, which is provided in Annexure 2.

CBCS (CHOICE BASED CREDIT SYSTEM) AND CAGP (CONTINUOUS ASSESSMENT AND GRADING PATTERN) OF EDUCATION AND ITS ADVANTAGES

CBCS is a proven, advanced mode of learning in higher education. It facilitates students to have freedom in making their own choices for acquiring a Degree / Master's Degree program. It is more focused towards the student's choice in providing a wide range of Units available in a single campus across various disciplines offered by experts in the subjects. It leads to quality education with active teacher-student participation.

Studying under CBCS has following advantages:

- Students may undergo training in cross-disciplinary and multi-disciplinary subjects and acquire more focused and preferred knowledge.
- Students may get more skills from other subject(s) which are required for the career path in addition to their regular subject knowledge.
- Students may get ample opportunities to use the laboratories and gain practical exposure to the much-needed Units available in other departments/schools for want of scientific inputs.
- Courses are conducted by subject experts identified based on their experiences. Courses taught by such experts may provide in-depth information and clear understanding of the Units.
- Students may get an opportunity to study courses with other students of different programs and exchange their views and knowledge in a common class room.
- CBCS provides a cross-cultural learning environment.
- Students may benefit much from selecting the right options to successfully face the public service examinations like UPSC, KPSC, IES wherein the knowledge of additional subjects become mandatory for general or optional papers.
- Students are exposed to the culture of universal brotherhood during their campus life.
- Students can practice various methods of learning a subject.

Summary of REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Post Graduate Degree Program

CBCS is a proven, advanced mode of learning in higher education. It facilitates students to have freedom in making their own choices for acquiring a Degree / Master Degree program. It is more focused towards the student's choice in providing a wide range of modules available in a single campus across various disciplines offered by experts in the subjects. It leads to quality education with active teacher-student participation.

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BRIEF OUTLINE OF REVA UNIVERSITY REGULATIONS FOR CHOICE BASED CREDIT SYSTEM (CBCS) AND CONTINUOUS ASSESSMENT GRADING PATTERN (CAGP) FOR M.Sc. PROGRAM IN CHEMISTRY, 2017

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.

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

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

The total credits earned by a student at the end of the semester upon successfully completing the course are L + T + P. The credit pattern of the course is indicated as L: T: P.

If a course is of 4 credits, then the different credit distribution patterns in L: T: P format could be:

4 : 0 : 0, 1 : 2 : 1, 1 : 1 : 2, 1 : 0 : 3, 1 : 3 : 0,

2 : 1 : 1, 2 : 2 : 0, 2 : 0 : 2, 3 : 1 : 0, 3 : 0 : 1,

0 : 2 : 2, 0 : 4 : 0, 0 : 0 : 4, 0 : 1 : 3, 0 : 3 : 1,

The concerned BoS will choose the convenient Credit Pattern for every course based on the requirement. However, generally, a course shall be of FOUR Credits and occasionally may be of TWO Credits.

Different Courses of Study are labeled 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 TWO types, viz. – (i) Hard Core Course, and (ii) Soft Core Course.

(i) 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.

(ii) 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.

Open Elective Course:

An elective course chosen generally from other discipline / subject, with an intention to seek exposure is called an Open Elective Course.

Project Work:

Project work is a special course involving application of knowledge in solving / analyzing /exploring a real-life situation / difficult problem. A project works up to FOUR credits is called Minor Project work. A project work of EIGHT or TWELVE credits is called Major Project work. A Minor Project work may be a hard core or a Soft Core as decided by the BoS / School Council concerned. But the Major Project shall be Hard Core.

Eligibility for Admission:

The eligibility criteria for admission to Master Program of 2years (4 Semesters) are given below:

Sl. No.	Program	Duration	Eligibility
1	Master of Science (Chemistry)	2 Years	Passed Bachelor's Degree of 3 years with Mathematics as major / optional subject with 45% marks (40% in case of candidate belonging to SC/ST category) of marks in aggregate of any recognized / institution or any other qualification recognized as equivalent there to.

Duration of the program and Medium of Instruction:

A Master's degree program is of 4 semesters - 2 years duration of 96 credits.

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 Foundation Courses with credits mentioned against them, common to all branches of study.

A candidate can enroll for a maximum of 24 credits per Semester including:

(i) Dropped Courses of corresponding semester(s) of previous year(s), if any:

(ii) Additional Courses from the corresponding Semester of immediate succeeding year.

However, a candidate may not successfully earn a maximum of 24 credits per semester.

Generally, a full-time candidate may register for 20 credits per semester.

Eligibility for Declaration of Ranks / Medals:

Only such candidates who register for a minimum of 16 credits per 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.

Continuous Assessment, Earning of Credits, and Award of Grades.

The assessment / evaluation of the candidate is based on continuous assessment. The structure for evaluation is as follows:

For assessment and evaluation, a semester is divided into 4 discrete components identified as IA1, IA2, and IA3 and Final

The performance of a candidate in a course will be assessed for a maximum of 100 marks as explained below. Scheme of Assessment & Evaluation

1. The Scheme of Assessment and Evaluation will have two parts, namely;

   i. Internal Assessment (IA); and
   ii. Semester End Examination (SEE)

2. Assessment and Evaluation of each Course shall be for 100 marks. The Internal Assessment (IA) and Semester End Examination (SEE) of UG non-engineering programs and PG programs shall carry 50 marks each (i.e., 50 marks internal assessment; 50 marks semester end examination).

3. The 50 marks of Internal Assessment (IA) shall comprise of:

Internal Test	= 30 marks
Assignments	= 10 marks
Seminars	= 10 marks

4. There shall be **three internal tests** conducted as per the schedule given below. T**he students have to attend all the three tests compulsorily.**

- **1st test** for 15 marks during **2nd part of the 6th week** of the beginning of the Semester;
- **2nd test** for 15 marks during **2nd part of the 13th week** of the beginning of the Semester; and
- **3rd test** for 15 marks during **2nd part of the 16th week** of the beginning of the Semester.

5. The coverage of syllabus for the said three tests shall be as under:

- For the **1st test** the syllabus shall be **First Unit and 1st half of Second Unit** of the Course;
- For the **2nd test** it shall be **Second half of Second Unit and Third Unit** of the Course;
- For the **3rd test** the syllabus will be **Fourth Unit** of the Course.

6. **Out of 3 tests, the highest marks secured in two tests are automatically considered while assessing the performance of the students.**

7. There shall be two Assignments and two Seminars each carrying 5 marks. Hence two assignments carry 10 marks (5+5 marks) and two seminars carry 10 marks (5+5 marks) as stated at Sl.No.3 above.

8. The Semester End Examination for 50 marks shall be held during 19th and 20th week of the beginning of the semester and **the syllabus for the semester end examination shall be entire 4 units**.

9. The **duration of the internal test shall be 75 minutes and for semester end examination the duration shall be 3 hours.**

10. The question papers for internal test shall be set by the internal teachers who have taught the course. If the course is taught by more than one teacher all the teachers together shall devise the question paper(s). However, these question papers shall be scrutinized by a Committee of senior teachers to bring in the uniformity in the question paper pattern and as well to maintain the quality of the question papers.

11. The test shall be common for all the students as it is prevailing today. The evaluation of the answer scripts shall be done by the internal teachers who have taught the course.

12. There shall be three sets of question papers for the semester end examination of which one set along with scheme of examination shall be set by the external examiners and two sets along with scheme of examination shall be set by the internal examiners. All the three sets shall be scrutinized by the Board of Examiners. It shall be the responsibility of the Board of Examiners Particularly Chairman of the BOE to maintain the quality and standard of the question papers and as well the coverage of the entire syllabus of the course.

13. There shall be double evaluation, viz, first valuation by the internal teachers who have taught the subject and second evaluation shall be the external examiner.

14. The average of the two evaluations (internal examiner & external examiner) shall be the marks to be considered for declaration of results.

Summary of Continuous Assessment and Evaluation Schedule

Type of Assessment	Period	Syllabus	Marks	Activity
Allocation of Topics for Assignments / Seminars / Model making	Beginning of 5th Week	First Unit and Second Unit		Instructional process and Continuous Assessment
First Internal Test	Second Part of 6th Week	First Unit and 1st half of Second Unit	15	Consolidation of First Unit and 1st half of Second Unit
Submission of Assignments	8th Week	First Unit and Second Unit	5	Instructional process and Continuous Assessment
Seminars	9th Week	First Unit and Second Unit	5	Instructional process and Continuous Assessment
Second Internal Test	2nd Part of 13th Week	2nd half of Second Unit and Third Unit	15	Consolidation of 2nd half of Second Unit and Third Unit
Allocation of Topic for 2nd Assignment / Seminars	11th Week	Third Unit and Fourth Unit		Instructional process and Continuous Assessment
Submission of Assignments	13th Week	Third Unit and Fourth Unit	5	Instructional process and Continuous Assessment
Seminars	14th Week	Third Unit and Fourth Unit	5	Instructional process and Continuous Assessment

Third Internal Test	2nd Part of 16th Week	Fourth Unit	15	Consolidation of entire Fourth Unit
Semester End Practical Examination	17th & 18th Week	Entire Syllabus	50	Conduct of Semester - end Practical Exams
Preparation for Semester–End Exam	17th & 18th Week	Entire Syllabus		Revision and preparation for semester–end exam
Semester End Theory Examination	19th and 20th Week	Entire Syllabus	50	Evaluation and Tabulation
	End of 21st Week			Notification of Final Grades

Note:

1. **As per the model making is concerned, the School shall decide about the Marks and the Number of Model Designs and as well the schedule of allocation and presentation of model design(s). If the model design carries 5 marks, there shall be two model designs; and in case of 10 marks, there shall be one model design. However, the decision of the School should be announced in the beginning of the Semester for students to avoid ambiguity and confusion.*

2. Examination and Evaluation shall take place concurrently and Final Grades shall be announced latest by 5 day after completion of the examination.

3. Practical examination wherever applicable shall be conducted after 3rd test and before semester end examination. The calendar of practical examination shall be decided by the respective School Boards and communicated well in advance to the Registrar (Evaluation) who will notify the same immediately.

14. Assessment of Performance in Practical's

14.1. The performance in the practice tasks / experiments shall be assessed on the basis of:

a) Knowledge of relevant processes;

b) Skills and operations involved;

c) Results / products including calculation and reporting

14.2. The 50 marks meant for continuous assessment of the performance in carrying out practical shall further be allocated as under:

i	Conduction of regular practical / experiments throughout the semester	20 marks
ii	Maintenance of lab records	10 marks
iii	Performance of mid-term test (to be conducted while conducting second test for theory courses); the performance assessments of the mid-term test includes performance in the conduction of experiment and write up about the experiment.	20 marks
	Total	**50 marks**

14.3. The 50 marks meant for Semester End (C3) 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**

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

15. 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 must submit final report of the project / dissertation, as the case may be, for final evaluation. The components of evaluation are as follows:

I	Periodic Progress and Progress Reports (25%)
Ii	Results of Work and Draft Report (25%)

Iii	Final Evaluation and Viva-Voce (50%). Evaluation of the report is for 30% and the Viva-Voce examination is for 20%.

16.0 Requirements to Pass a Course

16.1 A candidate's performance from IA and SEE will be in terms of scores, and the sum of IA and SEE scores will be for a maximum of 100 marks (IA = 50 + SEE = 50) and have to secure a minimum of 40% to declare pass in the course. However, a candidate has to secure a minimum of 25% (12.5 marks) in Semester End Examination (SEE) which is compulsory

16.2. **Eligibility to Appear for Semester - end Examination and Provision to Drop the Course.**

Only those students who fulfill 75% of attendance requirement are eligible to appear for Semester end examination in that course.

16.3. In case a candidate opts to drop the course he / she has to re-register for the dropped course only in subsequent semesters whenever it is offered if it is Hard Core Course. He / she may choose alternative course if it is Soft Core Course or Open Elective course or Skill Development Course.

The details of any dropped course will not appear in the Grade Card.

16.4. **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/open elective. **A DROPPED course is automatically considered as a course withdrawn.**

17. Provision for Make- up Examination:

17.2 **Re-Registration and Re-Admission:**

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

In case a candidate fails in more than 2 courses in odd and even semesters together in a given academic year, he / she may either drop all the courses and repeat the semester or reappear (SEE- semester end examination) to such of those courses where in the candidate has failed during subsequent semester / year within a stipulated period.

17.3 In such a case where in a candidate drops all the courses in 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.

17.4 **Requirements to Pass the Semester and Provision to Carry Forward the Failed Subjects / Courses:**

17.5 Provision to Carry Forward the Failed Subjects / Courses:

A student who has failed in 2 courses in 1st and 2nd semesters together shall move to 3rd semester. And he / she shall appear for semester end examination of failed courses of the said semesters concurrently with 3rd semester end examinations (SEE) and 4th semester end examinations (SEE) of second year of study.

18.0 Attendance Requirement:

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

18.2 In case a student is on approved leave of absence (eg:- 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.

18.3 Any student with less than 75% of attendance in a course in aggregate during a semester shall not be permitted to appear to the end semester (SEE) examination.

18.5 Teachers offering the courses will place the above details in the School / Department meeting during the last Wk. of the semester, before the commencement of SEE, and

subsequently a notification pertaining to the above will be brought out by the Head of the School before the commencement of SEE examination. A copy of this notification shall also be sent to the office of the Registrar & Registrar (Evaluation).

18.6 **Absence during mid semester examination**

In case a student has been absent from a mid-semester 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 permit such student to appear for make-up mid semester examination.

18.7 **Absence during end semester examination:**

In case a student is absent for end semester examination on medical grounds or such other exigencies, the student can submit request for make-up examination, with necessary supporting documents and certification from the concerned class teacher / authorized personnel to the concerned Director of the School. The Director of the School may consider such request depending on the merit of the case and after consultation with class teacher, course instructor and permit such student to appear for make-up mid semester examination

19. **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). This statement will not contain the list of DROPPED courses.

19.1 **Challenge Valuation:**

A student who desires to apply for challenge valuation shall obtain a Xerox copy of the answer script by paying the prescribed fee within 10 days after the announcement of the results. He / She can challenge the Grade awarded to him/her by surrendering the Grade Card and by applying along with the prescribed fee to the Registrar (Evaluation) within 15

days after the announcement of the results. This challenge valuation is only for Semester End Examination (SEE) component.

The answer scripts for which challenge valuation is sought for shall be sent to another external examiner. The marks awarded will be the higher of the marks obtained in the challenge valuation and in maiden valuation.

19.2 Final Grade Card: Upon successful completion of the Post Graduate Degree a Final Grade card consisting of grades of all courses successfully completed by the candidate will be issued by the Registrar (Evaluation).

19.3 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	Grade	Grade Point	Letter Grade
P	G	(GP=V x G)	
90-100	10	v*10	O
80-89	9	v*9	A
70-79	8	v*8	B
60-69	7	v*7	C
50-59	6	v*6	D
40-49	5	v*5	E
0-39	0	v*0	F

O - Outstanding; A-Excellent; B-Very Good; C-Good; D-Fair; E-Satisfactory; F - Fail;

Here, P is the percentage of marks (P=[(IA1+IA2)+M] 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.

19.4 **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 cored 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, i.e

SGPA (Si) = ∑(Ci x Gi) / ∑Ci

Where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} 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	B	8	4X8=32
Course 3	4	C	7	4X7=28
Course 4	4	O	10	4X10=40
Course 5	4	D	6	4X6=24
Course 6	4	O	10	4X10=40
	24			200

Thus, SGPA = 200 ÷ 24 = 8.33

Illustration No. 2

Course	Credit	Grade letter	Grade Point	Credit Point (Credit x Grade point)
Course 1	5	A	9	5X9=45
Course 2	5	C	7	5X7=35
Course 3	5	A	9	5X9=45
Course 4	5	B	8	5X8=40
Course 5	4	O	10	4X10=40
	24			205

Thus, SGPA = 205 ÷ 24 = 8.54

19.5 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 in Computer Science & Engineering is calculated taking into account all the courses undergone by a student over all the semesters of a program, i. e

CGPA = ∑(Ci x Si) / ∑Ci Where Si is the SGPA of the i^{th} 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:

CGPA after Final Semester

Semester (ith)	No. of Credits (Ci)	SGPA (Si)	Credits x SGPA (Ci X Si)
1	24	8.33	24 x 8.33 = 199.92
2	24	8.54	24 x 8.54 =204.96
3	24	9.35	24x9.35=224.4
4	24	9.50	24x9.50=228.0
Cumulative	96		857.28

Thus, **CGPA** = $\frac{24x8.33+24x8.54+24x9.35+24x9.50}{}$ = 8.93

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 8.93 x 10=89.30

19.6 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	Numerical Index	FGP Qualitative Index
> 4 CGPA < 5	**5**	SECOND CLASS
5 > = CGPA < 6	6	
6 >= CGPA < 7	7	FIRST CLASS
7 >= CGPA < 8	8	
8 >= CGPA < 9	9	DISTINCTION
9 >= CGPA 10	10	

Overall percentage=10*CGPA

20.0.Provision for Appeal

If a candidate is not satisfied with the evaluation of IA1, IA2 and IA3 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.

21. Grievance Cell

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

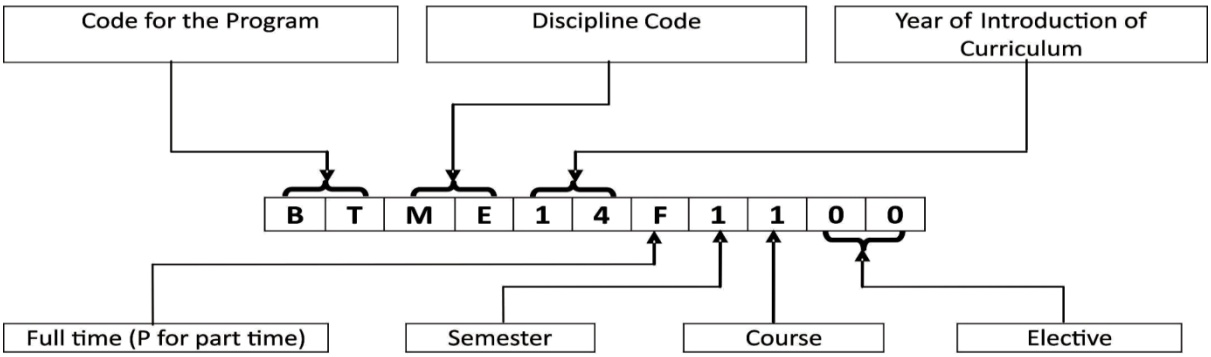
The Registrar (Evaluation) - Ex-officio Chairman / Convener

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.

22.0. With regard to any specific case of ambiguity and unsolved problem, the decision of the Vice-Chancellor shall be final.

Course Numbering Scheme



List of Codes for Programs and Disciplines / Branch of Study

Program	Title of the Program	Discipline Code	Name of the Discipline / Branch of Study
BA	Bachelor of Arts	AE	Advanced Embedded Systems
BB	BBM (Bachelor of Business)	AI	Advanced Information Technology
BC	B.Com (Bachelor of	AP	Advanced Power Electronics
BR	B. Arch (Bachelor of Architecture)	CA	Computer Aided Structural Engineering
BS	B Sc, BS (Bachelor of Science)	CE	Civil Engineering

BT	B.Tech (Bachelor of Technology)	CH	Chemistry
BP	Bachelor of Computer Applications	CO	Commerce
BL	LLB (Bachelor of Law)	CS	Computer Science and Engineering
MA	Master of Arts	DE	Data Engineering and Cloud
MB	MBA (Master of Business Administration)	EC	Electronics and Communication Engineering
MC	M.Com (Master of Commerce)	EN	English
MS	M.Sc / MS (Master of	MD	Machine Design and Dynamics
MT	M Tech (Master of	ME	Mechanical Engineering
MC	Master of Computer Applications	EE	Electrical & Electronics Engineering

M.Sc in CHEMISTRY: Program Overview

Chemistry often is viewed as fundamental to understand the life at molecular level. To understand and address the global challenges like environment and climate change, renewable and sustainable energy, material efficiency, health care and biotechnology, aerospace and transport a strong understanding of the chemical principles are extremely important. Therefore, an advanced knowledge in chemistry is highly essential to have a leading role in addressing these challenges and improve standard of living. This MSc Chemistry program is intended to impart and train the students in the core and important topics in chemistry domain. This program also makes students industry ready with training in laboratory skills and prepares students for research career in internationally reputed institutes.

Career Opportunities

The career opportunities for Post graduate in Chemistry students can be classified into the following categories:

- Academic Institutes/colleges as Lectures/Asst. Professors.
- Chemical companies as Research Associates/Scientists.
- Bio-pharma/Health Sector/Agrochemicals as Research Associates/Scientists.
- Research Institutes/IISc, IIT's, IISER's NIT's as Project assistants/PhD Scholars.

The curriculum is aimed to give strong both theoretical and practical foundation and hands-on exposure in the areas of R&D. The mandatory project work empowers the student to gain in-depth knowledge in his or her area of interest.

M Sc in Chemistry

Eligibility: Passed Bachelor's Degree of 3 years with Chemistry as major / optional subject with 45% marks (40% in case of candidate belonging to SC/ST category) of marks in aggregate of any recognized / institution or any other qualification recognized as equivalent there to.

M. Sc.-Chemistry - Scheme of Instructions -2017-18

Semester-I

SL No	Course Code	Course Title	Course Type	Credit pattern and value				Weekly Contact hours
				L	T	P	C	
1	MS17CH101	Inorganic Chemistry I	HC	3	1	0	4	5
2	MS17CH102	Organic Chemistry I	HC	3	1	0	4	5
3	MS17CH103	Physical Chemistry I	HC	3	1	0	4	5
4	MS17CH104	Analytical Chemistry I	HC	3	1	0	4	5
5	MS17CH106	Lab course in organic chemistry	HC	0	1	3	3	5
6	MS17CH107	Lab course in Physical chemistry	HC	0	1	3	3	5
Inorganic chemistry								
7	MS17CH115	Introduction to nano-science and nanotechnology (SC-1)	SC	3	1	0	4	5
Organic Chemistry								
8	MS17CH125	Heterocyclic chemistry(SC-1)	SC	3	1	0	4	5
Physical Chemistry								
9	MS17CH135	Surface, Interfaces and Catalysis (SC-1)	SC	3	1	0	4	5
Analytical Chemistry								
10	MS17CH145	Advanced Instrumental methods of analysis(SC-1)	SC	3	1	0	4	5
11		R&D		0	1	2	*	4
Total							**26**	**34**

Note: Students must choose any one softcore out of four softcore

* - Credits will be awarded at end of third semester on submission of mini-project report

Semester-II

Sl. No	Course Code	Course Title	Course Type	Credit pattern and value				Weekly Contact hours
				L	T	P	C	
1	MS17CH201	Inorganic Chemistry II	HC	3	1	0	4	5
2	MS17CH202	Organic Chemistry II	HC	3	1	0	4	5
3	MS17CH203	Physical Chemistry II	HC	3	1	0	4	5
4	MS17CH204	Analytical chemistry II – Organic Spectroscopy	HC	3	1	0	4	5
5	MS17CH206	Lab course in Inorganic chemistry	HC	0	1	3	3	5
6	MS17CH207	Lab course in Analytical chemistry	HC	0	1	3	3	5
Inorganic Chemistry								
7	MS17CH215	Chemistry of Life (SC-2)	SC	3	1	0	4	5
Organic Chemistry								
8	MS17CH225	Supramolecular and Medicinal Chemistry(SC-2)	SC	3	1	0	4	5
Physical chemistry								
9	MS17CH235	Advanced Chemical Kinetics and thermodynamics(SC-2)	SC	3	1	0	4	5
Analytical Chemistry								
10	MS17CH245	Separation techniques (SC-2)	SC	3	1	0	4	5

11		R&D	R&D	0	1	2	*	4
Total							**26**	**39**

Note: Students must choose any one softcore out of four softcore

* - Credits will be awarded at end of third semester on submission of mini-project report

Semester-III

Sl. No	Course Code	Course Title	Course Type	Credit pattern and value				Weekly Contact hours
				L	T	P	C	
1	***Inorganic Chemistry***							
	MS17CH311	Industrial inorganic chemistry (SC-3)	SC	3	1	0	4	5
	MS17CH321	Organometallics (SC-4)	SC	3	1	0	4	5
	MS17CH331	Solid state chemistry and Advanced Materials (SC-5)	SC	3	1	0	4	5
	MS17CH341	Structural methods in inorganic chemistry (SC-6)	SC	3	1	0	4	5
	MS17CH351	Advanced Inorganic Chemistry (SC-7)	SC	3	1	0	4	5
2	***Organic Chemistry***							
	MS17CH312	Advanced Organic Chemistry (SC-3)	SC	3	1	0	4	5
	MS17CH322	Advanced Organic Synthesis (SC-4)	SC	3	1	0	4	5
	MS17CH332	Natural Products and Bioorganic Chemistry (SC-5)	SC	3	1	0	4	5
	MS17CH342	Organometallic Chemistry in organic Chemistry (SC-6)	SC	3	1	0	4	5
	MS17CH352	Green Chemistry (SC-7)	SC	3	1	0	4	5
3	***Physical Chemistry***							

	MS17CH313	Photophysical processes and Applications (SC-3)	SC	3	1	0	4	5
	MS17CH323	Energy and Energy conversion systems (SC-4)	SC	3	1	0	4	5
	MS17CH333	Advanced Physical Chemistry (SC-5)	SC	3	1	0	4	5
	MS17CH343	Polymer Science and Technology (SC-6)	SC	3	1	0	4	5
	MS17CH353	Fundamentals of Electrochemistry and applications (SC-7)	SC	3	1	0	4	5
4	***Analytical Chemistry***							
	MS17CH314	Environmental chemistry and Applied analysis (SC-3)	SC	3	1	0	4	5
	MS17CH324	Advanced Surface analysis and electron spectroscopy (SC-4)	SC	3	1	0	4	5
	MS17CH334	Water chemistry and treatment technology (SC-5)	SC	3	1	0	4	5
	MS17CH344	Fundamentals of Electroanalytical techniques (SC-6)	SC	3	1	0	4	5
	MS17CH354	Advanced analytical Chemistry (SC-7)	SC	3	1	0	4	5
	MS17CH305	Lab course in Inorganic chemistry	HC	0	1	3	3	5

	MS17CH306	Lab course in organic chemistry	HC	0	1	3	3	5
			OE	3	1	0	4	5
	MS17CH307	R&D – Mini Project (related to soft core)	SC	0	1	2	2*	4
Total							**28**	**39**

Note: Students must choose any four soft cores out of four specializations softcore

* - Credits will be awarded at end of third semester on submission of mini-project report

Semester-IV

Sl. No	Course Code	Course Title	Course Type	Credit pattern and value				Weekly Contact hours	Teaching School
				L	T	P	C		
1	MS17CH401	Project	HC	--	--	--	16	--	--
2	M17CH 4024	ADVANCED ELECTROANALYTICAL TECHNIQUES	SC-04	2	1	0	3	4	----

Credits Semester wise

Semester	I	II	III	IV	Total
HC-Theory	4x4 =16	4x4 =16	-----	-----	32
HC-Lab	2x3=6	2x3=6	2x3=6	-----	18
SC-Theory	1x4=4	1x4=4	4x4=16	-----	24
R&D	-----	-----	2*	-----	2

OE	-----	-----	1x4=4	-----	4
Project	-----	-----	-----	16	16
Total	**26**	**26**	**28**	**16**	**96**

M. Sc-Chemistry

Scheme of Examination

Semester-I

S. No	Course Code	Course Title	Credits	Exam Duration	Marks			
					C1	C2	C3	Total
1	MS17CH101	Inorganic Chemistry I	4	3	25	25	50	100
2	MS17CH102	Organic Chemistry I	4	3	25	25	50	100
3	MS17CH103	Physical Chemistry I	4	3	25	25	50	100
4	MS17CH104	Analytical Chemistry I	4	3	25	25	50	100
5	MS17CH106	Lab course in organic chemistry	3	5	25	25	50	100
6	MS17CH107	Lab course in Physical chemistry	3	5	25	25	50	100
Inorganic chemistry								
7	MS17CH115	Introduction to nano-science and nanotechnology (SC-1)	4	3	25	25	50	100
Organic Chemistry								
8	MS17CH125	Heterocyclic chemistry (SC-1)	4	3	25	25	50	100
Physical Chemistry								

9	MS17CH135	Surface, Interfaces and Catalysis (SC-1)	4	3	25	25	50	100
Analytical Chemistry								
10	MS17CH145	Advanced Instrumental methods of analysis (SC-1)	4	3	25	25	50	100
11*		R&D						
Total Credits			26					

Note: Students must choose any one softcore out of four softcore

* - Credits will be awarded at end of third semester on submission of mini-project report

Semester-II

S. No	Course Code	Course Title	Credits	Exam Duration	Marks			
					C1	C2	C3	Total
1	MS17CH201	Inorganic Chemistry II	4	3	25	25	50	100
2	MS17CH202	Organic Chemistry II	4	3	25	25	50	100
3	MS17CH203	Physical Chemistry II	4	3	25	25	50	100
4	MS17CH204	Analytical chemistry II – Organic Spectroscopy	4	3	25	25	50	100
5	MS17CH206	Lab course in Inorganic chemistry	3	5	25	25	50	100
6	MS17CH207	Lab course in Analytical chemistry	3	5	25	25	50	100

Inorganic Chemistry								
7	MS17CH215	Chemistry of Life (SC-2)	4	3	25	25	50	100
Organic Chemistry								
8	MS17CH225	Supramolecular and Medicinal Chemistry (SC-2)	4	3	25	25	50	100
Physical chemistry								
9	MS17CH235	Advanced Chemical Kinetics and thermodynamics (SC-2)	4	3	25	25	50	100
Analytical Chemistry								
10	MS17CH245	Separation techniques (SC-2)	4	3	25	25	50	100
11*		R&D						
Total			26					

Note: Students must choose any one softcore out of four softcore

* - Credits will be awarded at end of third semester on submission of mini-project report

Semester-III

S. No	Course Code	Course Title	Credits	Exam Duration	Marks			
					C1	C2	C3	Total
1	***Inorganic Chemistry***							

	MS17CH311	Industrial inorganic chemistry (SC-3)	4	3	25	25	50	100
	MS17CH321	Organometallics (SC-4)	4	3	25	25	50	100
	MS17CH331	Solid state chemistry and Advanced Materials (SC-5)	4	3	25	25	50	100
	MS17CH341	Structural methods in inorganic chemistry (SC-6)	4	3	25	25	50	100
	MS17CH351	Advanced Inorganic Chemistry (SC-7)	4	3	25	25	50	100
2	***Organic Chemistry***							
	MS17CH312	Advanced Organic Chemistry (SC-3)	4	3	25	25	50	100
	MS17CH322	Advanced Organic Synthesis (SC-4)	4	3	25	25	50	100
	MS17CH332	Natural Products and Bioorganic Chemistry (SC-5)	4	3	25	25	50	100
	MS17CH342	Organometallic Chemistry in organic Chemistry (SC-6)	4	3	25	25	50	100
	MS17CH352	Green Chemistry (SC-7)	4	3	25	25	50	100
3	***Physical Chemistry***							
	MS17CH313	Photophysical processes and Applications (SC-3)	4	3	25	25	50	100

	MS17CH323	Energy and Energy conversion systems (SC-4)	4	3	25	25	50	100
	MS17CH333	Advanced Physical Chemistry (SC-5)	4	3	25	25	50	100
	MS17CH343	Polymer Science and Technology (SC-6)	4	3	25	25	50	100
	MS17CH353	Fundamentals of Electrochemistry and applications (SC-7)	4	3	25	25	50	100
4	***Analytical Chemistry***							
	MS17CH314	Environmental chemistry and Applied analysis (SC-3)	4	3	25	25	50	100
	MS17CH324	Advanced Surface analysis and electron spectroscopy (SC-4)	4	3	25	25	50	100
	MS17CH334	Water chemistry and treatment technology (SC-5)	4	3	25	25	50	100
	MS17CH344	Fundamentals of Electroanalytical techniques (SC-6)	4	3	25	25	50	100
	MS17CH354	Advanced analytical Chemistry (SC-7)	4	3	25	25	50	100
	MS17CH305	Lab course in Inorganic chemistry	3	5	25	25	50	100

	MS17CH306	Lab course in Physical organic chemistry	3	5	25	25	50	100
	#	OE	4	3	25	25	50	100
	MS17CH307	R&D – Mini Projects (related to soft core)	2					
	Total		28					

Note: Students must choose any four soft cores out of four specializations softcore

* - Credits will be awarded at end of third semester on submission of mini-project report.

#-Will be given by other schools.

Semester-IV

S. No	Course Code	Course Title	Credits	Exam Duration	Marks			
					C1	C2	C3	Total
1	MS17CH401	Project	16	---	---	---	---	100

M.Sc. CHEMISTRY DETAILED SYLLABUS

INORGANIC CHEMISTRY

SEMESTER-I: HARD CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH101	**16 Weeks**	**Inorganic Chemistry – 1**	**3**	**1**	**0**	**4**

Course Objectives: To make the student conversant with

i. The Structure, bonding and properties through Lewis, VSEPR, Valence bond and Molecular orbital theory.

ii. 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. The HSAB rule, Isopoly, Hetropolyacids and non-aqueous solvents.

iv. The structures, bonding and stability of Metal Clusters and Nuclear Chemistry.

Course Outcomes:

By the completion of course student will be able to:

2. Discuss the principles of bonding, predicting the geometries of simple molecules and properties through VSEPR, Valence bond and Molecular orbital theory.
3. 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.
4. Classify the substances softness and hardness by using HSAB rule and discuss the properties of non-aqueous solvents.
5. Apply the acquired knowledge to explain the structure, bonding and stability of Metal Clusters, Pnictogens, Chalcogens, Halogens and Nobel Gases.

Mapping of Course Outcomes with Pos and PSOs

Course Code	POs/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
MS17CH101	CO1	2	2	0	1	1	0	0	0	0	1	3	2	1
	CO2	3	2	0	1	1	1	0	0	0	1	3	2	1
	CO3	2	1	1	0	1	1	0	0	0	1	3	2	1
	CO4	2	1	1	1	2	2	0	0	0	1	2	2	3

UNIT-I

Periodicity and chemical bonding: Periodic properties, atomic states and term symbols. Bonding and structure; Types of bonds, orbital symmetry and overlaps, concept of MO and VB theory, concept of hybridization, bond energy and covalent radii, concept of resonance, molecular dipole moment; polarizing power and polarizability, Fajan's rules.

VSEPR model, shapes of molecules-ClF_3, ICl_4^-, TeF_5^-, I_3^-, $TeCl_6^{2-}$, XeF_6, $SbCl_6^{3-}$, IF_7, ReF_7, XeF_8^{2-}, TaF_8^{3-}; Bent rules and energetics of hybridization; electronegativity and partial ionic character; Bonds-Multicenter, Synergic and Agostic bonding. Lattice energy: Born-Lande equation, Kapustinskii equation, partial covalent character, radius-ratio rules, structures of simple solids, Zintl- isoelectronic relationship in solids. Molecular orbital theory: LCAO and MO diagrams of heteronuclear diatomic (CO, NO, HF, ICl) and triatomic molecules (CO_2 and NO_2^-).

[15 hrs]

UNIT-II

Chemistry of main group elements: Periodic anomalies in main block elements, Inert Pair effect, Relativistic effect, Diborane and its reactions, polyhedral boranes, (Preparation, properties, structure and bonding). Wade's rules, carboranes and borazines. Inorganic chains, rings and cages of boron, carbon and phosphorous.

Silicates: Structure, classification - silicates with discrete anions, silicates containing chain anion, silicates with layer structure, silicones with three-dimensional network and Applications.

Silicone: General methods of preparation, properties. Silicone polymers - silicone fluids, Silicone greases, silicone resins, silicone rubbers and their applications.

Heterocyclic inorganic ring system: Sulphur-nitrogen ring, nitrogen-phosphorous ring. **[15 hrs]**

UNIT-III

HSAB concept: Basis of HSAB concept, acid-base strength, hardness and softness, symbiosis, applications of HSAB concept; Acid- base concept in non-aqueous media, reactions in BrF_3, N_2O_4, anhydrous H_2SO_4, CH_3COOH. Isopoly and heteropoly acids of W, Mo and V, preparations, properties, structure and applications.

Non-aqueous solvents: Classification of solvents, Properties of solvents (dielectric constant, donor andacceptor properties) protic solvents (anhydrous H_0SO_4, HF and glacial acetic acid) aprotic solvents (liquidSO_2, BrF_3 and N_2O_4). Solutions of metals in liquid ammonia, hydrated electron. Super acids.

[15 hrs]

UNIT-IV

Clusters, cages and Nuclear Chemistry: 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 clusters, Wades-Mingos and Lauher rules.

Nuclear Chemistry - The atomic nucleus-elementary particles, quarks, classification of nuclides based on Z and N values, nuclear stability, nuclear potential, binding energy. Nuclear Models: Shell model-salient features, forms of the nuclear potential, filling of orbitals, nuclear configuration, Liquid drop model, Fermi gas model, Collective model and Optical model. Radioactivity, radioactive decay kinetics, Parent-daughter decay-growth relationship-secular and transient equilibria, theories of α, β- , β+ and γ-decay, internal conversion, Auger effect**.** **[15 hrs]**

Reference Books:

1. Basic Inorganic Chemistry – 3rd edition. F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons (2002).
2. Inorganic Chemistry, 3rd edition. James E. Huheey, Harper and Row Publishers (1983).
3. Inorganic Chemistry, 3rd edition. 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).

SEMESTER-I: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH115	**16 Weeks**	**Introduction to Nano-science and Nano-technology**	**3**	**1**	**0**	**4**

Course Objectives: To make the student conversant with

i. The introduction to nanotechnology.

ii. Classification of nanostructures and the methods of synthesizing

iii. The various Nanomaterials characterization techniques nanomaterials and Carbon nanomaterials.

iii. The applications of nanomaterials in nanoelectronics and Biochemical sensor

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Course Outcomes: By the completion of course student will be able to

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

2. Categorize the Types of Nanostructures includes carbon nanomaterials and discuss the preparation, properties and applications.
3. Describe the various types of nanomaterials characterization techniques like Imaging techniques and Spectroscopic techniques.
4. Apply the acquired theoretical knowledge to classify as nanocatalysts, chemical sensors, biosensors, drug delivery, Biochemical sensor, Biophysical sensor and nano electronics**.**

Mapping of Course Outcomes with POs and PSOs

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
MS 17 CH 115	CO1	2	2	1	2	1	1	0	0	0	1	3	1	1
	CO2	2	2	2	2	1	1	0	0	0	1	3	1	1
	CO3	2	1	2	1	1	1	0	0	0	1	3	2	2
	CO4	2	1	2	2	2	1	0	0	0	1	3	2	3

UNIT-I

Background to Nanotechnology: Atom, molecules and nanoscale materials, Electrons in nanostructures, Quantum size effects, Density of states, particle in box model, Gibb's energy at nanoscale, Q dots, Q wires, Q walls, property variations in nanoscale. 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. **[15 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

Carban 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

Metals and semiconducators nanomaterials: (Au, Ag) – Metal oxides (TiO2, CeO2, ZnO) – Semiconductors (Si, Ge, CdS, ZnSe) – Ceramics and Composites – Dilute magnetic semiconductor- Biological system – DNA and RNA – Lipids. **[15 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).

Spectroscopic techniques: Infra-red spectroscopy (IR)- UV-visible-Absorption and reflection-Raman Scattering –MicroRaman-tipenhanced Raman-Surface Enhanced Raman scattering (SERS)– Photoluminescence (PL)– Cathodeluminescence (CL). **[15 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). **[15 hrs]**

Reference Books:

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

SOFTCORE – 03

Course Code	Course Title	Type	L	T	P	C	Hrs/ Week
M17CH 1053	SURFACE, INTERFACE AND CATALYSIS	SC	2	1	0	3	4

Course Objective: This course aims to provide the student to

a. Correlate the topics like Surface phenomena of solids, solid-liquid interfaces, Homogenous and Heterogeneous Catalysis and Instrumental methods of catalyst characterization.
b. Illustrate Homogenous and Heterogeneous Catalysis and Instrumental methods of catalyst characterization. Describe the *lock-and-key* and *induced-fit* models of enzyme action.

c. Explain the function of a catalyst in terms of reaction mechanisms and potential energy diagrams
d. Gain the Knowledge of Catalyst characteristics, Mechanism of catalytic reactions and design of catalytic Reactor.

Course Outcomes:

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 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
M18 CH 1053	**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 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. Dynamics and energetics of surfaces. Adsorption from solution and gas on surface. [12hr]

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. [12 hr]

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 heterogenous catalytic processes. [12 hr]

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. [12 hr]

Reference Books:

1. A. Zangwill, Physics at Surfaces, Cambridge Univ. Press, 1988.
2. B. Gates, Catalytic Chemistry, Wiley, 1992.
3. A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces, Wiley, 1997.
4. J. M. Thomas and W.J. Thomas, Principles and Practice of Heterogeneous Catalysis, Wiley-VCH, 1997.
5. K.W. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience, Wiley, 2002.
6. D.K. Chakrabarty and B. Viswanathan, Heterogeneous Catalysis, New Age, 2008.
7. G.A. Somorjai, Y. Li , Introduction to Surface Chemistry and Catalysis, Wiley, 2010.
8. Physical chemistry of surfaces by Arthur W. Adamson 1990

9. Chemical kinetics and catalysis by R.I. Masel, Wiley-Interscience, 2001.
10.The chemical physics of surfaces by 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 by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.
13. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, New York, 1993.

SEMESTER-II: HARD CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH201	**16 Weeks**	**Inorganic chemistry –II**	**3**	**1**	**0**	**4**

Course Objectives: This course on inorganic chemistry,

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

Course Outcomes:

After successful completion of the course students shall 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 Gouy's ,VSM and faraday's 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 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
M18CH2010	**CO1**	**3**	**1**	**0**	**2**	**1**	**1**	**0**	**2**	**0**	**2**	**1**	**2**	**0**
	CO2	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**2**
	CO3	**3**	**2**	**1**	**2**	**0**	**2**	**0**	**2**	**2**	**2**	**1**	**1**	**2**
	CO4	**2**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**1**	**3**

.

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, Ligand substitution reactions in octahedral and square planar complexes, factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand, chelate effect, macrocyclic effect and their thermodynamic origin. Determination of binary formation constant by pH metry, spectrophotometry, polarography and ion exchange methods.

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

UNIT- II

Metal- ligand bonding: Stereoisomerism- coordination numbers 3 to 8. 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, 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: tetrahedral and octahedral complexes (including π-bonding), 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, 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, CT spectra. Spectral properties of Lanthanide and Actinide metal complexes. **[15 hrs]**

UNIT– IV

Magnetic properties of coordination compounds: Types of magnetic behaviour, magnetic susceptibility and its determination- Gouy, Faraday, VSM method. 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. Photochemical reactions of transition metals complexes: Basic photochemical processes, Kasha's rule, quantum yield, Jabolnskii diagrams, photo substitution reactions, photo-redox reactions, ligand photoreactions, photoreactions and solar energy conversion.

[15 hrs]

Reference Books:

1. Basic Inorganic Chemistry- F. A. Cotton, G. Wilkinson and P. L. Gaus; John Wiley and sons. Inc, 6th edition (1999).
2. Chemistry of elements- N. N. Greenwood and A. E. Earnshaw, Butterworth Heinemann (1997).
3. Inorganic Chemistry IV edition; J. E. Huheey, E. A. Keiter and R. L. Keiter, Addison; Wesley (1993).
4. Inorganic Chemistry, II 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 by W. W. Porterfield, Elsevier 2005 2nd edition.
9. Textbook of inorganic chemistry by G. S. Sodhi, Viva books Pvt. Ltd (20

SEMESTER II: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH215	16 Weeks	Chemistry of Life	3	1	0	4

Course Objectives: This course intends to provide information on;

1. Knowledge on green chemistry concepts
2. Applications of various green technology in materials synthesis
3. Class of green chemicals and compounds for sustainability
4. Categorisation of reaction mechanisms and schemes for green synthesis

Course outcomes:

CO1 Discriminate the role metal ions in biological systems

CO2 Categorise 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 Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO1	1	1	0	0	2	2	0	0	0	0	2	2	0
	CO2	2	1	0	1	2	1	0	0	0	0	1	2	2
	CO3	2	2	0	1	2	2	0	0	0	0	2	0	2
	CO4	2	2	0	2	2	2	0	0	0	0	2	2	2

UNIT-I

Bioinorganic chemistry: Occurrence of elements, specific ligands, and coordination sites in biomolecules. Role of metal ion concentration and its effects, Basic principle of selection of metal ions in biosystems, Transport and storage of K^+, Ca^{2+} and Iron. Role of haemoglobin and myoglobin in transport and storage of oxygen. Spin state of iron, Spatial and electronic aspects in dioxygen binding, Electron Transfer: Cytochromes, Fe-S Clusters and Copper-Blue proteins. Catalysis: Acid-Base Catalyses (Zn, Mg and Fe enzymes), Peroxidases. Molybdenum and tungsten enzymes. Nitrogen cycle. Bio mineralization. Applications: Sensing and medicinal. Anti cancer drug – Cisplatin, Structural aspects of Chlorophyll, Photo system I & II, Vitamin B_6 structure.

Bioenergetics: Introduction, Redox reactions in metabolism, the central role of ATP in Metabolism. Kinetic stability of ATP, Mitochondrial flow of electrons from NADH to O_2. Oxidative phosphorylation and respiratory chain.

Vitamin B12 and Coenzymes: Structural feature, names of different forms, chemistry of Cobalamin, biochemical functions of cobalamins, model compounds. Special characteristics of B_{12} co-enzyme. **[20 hrs]**

UNIT-II

Biophysical chemistry: Chemistry and biology of water. Chemical forces responsible for stability of biomolecules; hydrogen bonding; electrostatic interactions, hydrophobic interactions; stacking interactions; covalent bonding; thermodynamic principles-of Biosystems-coupled reactions and protein folding; enzymes, catalysis, and kinetics- Michaelis-Menten equation, and Lineweaver–Burk plot; enzyme inhibition and different types of enzyme inhibition. Electrophoresis - principles of free electrophoresis, zone

electrophoresis, gel electrophoresis and its applications in qualitative and quantitative study of proteins. Determination of isoelectric point of a protein. Electroosmosis and streaming potential and its biological significance. Biological significance of Donnan membrane phenomenon. Micelles and its involvement during digestion and absorption of dietary lipids. Diffusion of solutes across biomembranes and its application in the mechanism of respiratory exchange. “Salting In” and “Salting Out” of proteins. Osmotic behaviour of cells and osmoregulation and its application in the evolution of excretory systems of organisms. Effect of temperature and *p*H on the viscosity of biomolecules (albumin solution). Significance of viscosity in biological systems - mechanism of muscle contraction, detection of intrastrand disulfide bonds in proteins, polymerization of DNA and nature of blood flow through different vessels. Effect of temperature, solute concentration (amino acids) on surface tension. **[20 hrs]**

UNIT-III

Bioorganic chemistry: Biopolymers-DNA, RNA and Proteins- structures of monomers, bonding, and hierarchy of structural organization. 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.

Metal ion transport and storage:

Iron storage and transport: Transferrin, ferratin, phosvitin and gastroferrin. Iron transport in microbes: siderophores, *in vivo* microbial transport of iron.

Oxygen transport and oxygen uptake proteins: Properties of dioxygen (O_2): Thermodynamic and kinetic aspects of dioxygen as an oxidant, activation of dioxygen through complexation with metal ions.Haemoglobin (Hb) and Myoglobin (Mb) in oxygen transport mechanism: Introduction to porphyrin system, substituent effects on porphyrin rings, functions of Hb and Mb. Characteristics of O_2- binding interaction with Hb and Mb. Model compounds for oxygen carriers (Vaska's complex and cobalt(III) – Schiff base complexes). Hemerythrin and hemocyanin.

Electron transport proteins and redox enzymes: Iron – sulfur proteins (rubredoxins and ferredoxins) and cytochromes including cytochrome P450. Catalase and peroxidase: Structure and reactivity. Superoxide dismutase: Structure and reactivity.

Molybdenum containing enzymes: Aspects of molybdenum chemistry, Xanthine oxidase, aldehyde oxidase, sulfite oxidase, nitrogenase and nitrite reductase.

Non-redox metalloenzymes - Structure and reactivity: Carboxypeptidase-A, alcohol dehydrogenase, leucine aminopeptidase and carbonic anhydrase . **[20 hrs]**

Reference Books:

1. W. Kaim.; Bioinorgnic Chemistry, 2nd Edition, John Wiley. 2013.
2. D. F. Shriver, P. W. Atkins, C. H. Langford, Inorganic Chemistry, ELBS. 1990.
3. C.R. Cantor & P.R. Schimmel, Biophysical Chemistry, W.H.Freeman& Company, 1980
4. David Van Vranken and Gregory A, Introduction to Bioorganic Chemistry and Chemical Biology. Garland Science (Taylor & Francis), 2012.
5. R.H. Thomson, Chemistry of Natural Products - Wiley, New York, 1996.
6. I.L. Finar, Advanced Organic Chemistry, Vol. 2 ELBS, New Delhi, 1975.
7. Bhat, S.V., Nagasampagi, B.A., Meenakshi, S. (2009). *Natural Product Chemistry & Applications*, Narosa Publishing House, New Delhi.

SEMESTER: II - INORGANIC PRACTICALS

Course Code	Duration	Course Title	L	T	P	C
MS17CH206	**16 Weeks**	Lab course in Inorganic chemistry	**3**	**1**	**0**	**4**

Course Objectives: This course aims to provide the student to

a. Correlate To expose the students to a breadth of experimental techniques using modern instrumentation.
b. To provide a broad foundation in Chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. endeavours to contribute to industry and address problems of societal importance.
c. Design To make the Department a growing center of excellence in teaching, cutting-edge research, curriculum development and popularizing Chemistry.
d. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions,

protocols, standard laboratory equipment, and modern instrumentation.

Course Outcomes:

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 UVVis, 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	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3

Code														
M18 CH 2070	**CO 1**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**1**	**0**
	CO 2	**2**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**3**	**2**	**1**
	CO 3	**3**	**2**	**2**	**2**	**3**	**2**	**1**	**3**	**3**	**2**	**3**	**2**	**3**
	CO 4	**2**	**2**	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**3**	**2**	**3**

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.

Reference Books:

1. Vogel's Text Book of Quantitative Chemical Analysis – 5th edition, J. Basset, R.C.Denney, G.H. Jeffery and J. Mendhom.
2. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel, 3rd edition.
3. Spectrophotometric Determination of Elements by Z. Marczenko.
4. Vogel's Qualitative Inorganic Analysis – Svelha.
5. Macro and Semimicro Inorganic Qualitative Analysis by A.I. Vogel.
6. Semimicro Qualitative Analysis by F.J. Welcher and R.B. Halin.
7. Quantitative Chemical Analysis by Daniel C. Harris, 7th edition, (2006).

SEMESTER-III: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH311	**16 Weeks**	**Industrial inorganic chemistry**	**3**	**1**	**0**	**4**

Course Objectives: This course intended to provide student to

a. Conclude the preparation of some industrial inorganic products and challenges in the production.

b. 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.

c. Appraise the importance of inorganic chemical industry, their economic impact, individual chemical processes and production challenges.

d. Develop practical skills to synthesis of industrial inorganic compounds by the acquired knowledge.

Course outcomes:

Upon successful completion of this course, the 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 Outcomes	Program Outcomes												
	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
CO-1	2	1	2	0	0	1	0	0	1	1	2	0	1
CO-2	1	1	1	0	0	1	1	0	1	1	2	0	1
CO-3	1	0	1	0	1	2	1	1	1	1	2	0	0
CO-4	1	1	1	0	1	1	1	1	1	1	1	0	0

UNIT-I

Raw Materials and Energy for Chemical Industry Raw materials: Characteristics of raw materials and their resources – methods of raw material concentrations–integral utilization of raw materials. Energy for chemical industry–Fuels–classification of fuels–coal–fuel gases and liquid fuels–petroleum–cracking–Octane number–cetane number–composition and uses of coal gas, water gas, producer gas, oil gas and gobar gas. [15 hrs]

UNIT-II

Surfactants, Explosives, Pesticides Surfactants: Classification with examples, Adsorption and micelle formation, Manufacture of anionic, cationic, zwitterionic and nonionic detergents, Applications in industries Applications as Foaming agent, Wetting agent, Dispersant, Solubilizers, Emulsifiers and Rheology modifiers, Detergent formulations, Detergent biodegradation, Biosurfactants. Explosives: Classification, characteristics, preparation of nitrocellulose-T.N.T, Picric acid, Dynamite-cordite and Gunpowder, Dynamite, HMX, PETN, Cyclonite, plastic explosives, gelatin, RDX, cordite and seismic explosives, propellants- manufacture of liquid and solid propellants-hydrazine, incendiaries and smoke screens. Industrial applications. Pesticides: Introduction, classification, synthesis of few common pesticides of chlorinated (DDT, BHC, Chlordane, Aldrin), organophosphorus and carbamate (parathion, Malathion, carbaryl) compounds family, Plant pesticides, Pesticide formulations. [15 hrs]

UNIT-III

Cement, Ceramics, Polymeric Materials, Glass, Paints and Fertilizers Cement: Manufacture – Wet Process and Dry process. Types, Analysis of major constituents, setting of cement, reinforced concrete. Cement industries in India. Ceramics: Important clays and feldspar, glazing and verification. Polymeric Materials: Industrial polymers (Thermoplastics polymers and thermosetting Polymers) and composite materials– their constitutions, chemical and physical properties, Industrial applications. Glass: Types, Composition, manufacture of Optical glass, colored glasses, lead glass and neutron absorbing glass. Fertilizers: Fertilizer industries in India, Manufacture of ammonia, ammonium salts, urea, superphosphate, triple superphosphate and nitrate salts. Paints: Components of paints, pigments, thinner, binder, types of paints, water based paints, drying of paints. [15 hrs]

UNIT-IV

Industrial Hygiene and Chemical Safety: (a) Industrial hygiene: Concept, air and biological monitoring, occupational disease, operational control measures, personal protective equipments; (b) Industrial hazards and Safety: Process hazards checklists, hazard surveys, safety program, Hazop safety reviews. c) Industrial pollution: Classification of hazards chemicals, storage, transportation, handling, risk assessments, challenges/solutions (d)Eco-friendly effluents disposal: Water pollutants, health hazards, sampling and analysis of water, water treatment, different industrial and domestic effluents and their treatment and disposal, advanced waste water treatment, effluent quality standards and laws, chemical industries, tannery, dairy, textile effluents, common treatment. **[15 hrs]**

Reference Books:

1. Norris Shreve, R. and J.A. Brink (1977): Jr. Chemical Process Industries. 4th edn.McGrawHill, Tokyo.

2. Chakrabarty, B.N (1981): Industrial Chemistry, Oxford & IBH Publishing Co., New Delhi.

SEMESTER-III: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH321	16 Weeks	Organometallics	3	1	0	4

Course objectives

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

2. 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.

3. 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.

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

Course Outcomes

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

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

2. Recognize the typical organometallic reactions, explain their mechanisms and interpret them

reactivity based on the structure.

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

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

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PO9	PO 10	PSO 1	PSO 2	PSO 3
	CO 1	2	1	1	2	2	1	0	0	1	1	3	1	0
	CO 2	3	3	1	2	1	1	0	0	1	1	2	1	1

	CO 3	3	2	1	2	1	1	0	0	2	3	2	1	1
	CO 4	3	3	1	1	1	1	0	0	2	2	2	1	1

UNIT-I

Organometallic Chemistry 1: Compounds with transition metal to carbon bonds: classification of ligands, nomenclature, eighteen electron rule; transition metal carbonyls: range of compounds and structure, bonding, vibrational spectra, preparation, reactions; transition metal organometallics: square planar complexes, metal alkyls, metal alkylidenes and metal alkylidynes; Structure and bonding: metal-olefin bond and arenemetal bond. **[15 hrs]**

UNIT-II

Organometallic Chemistry 2: Compounds with ligands having extended pi systems: bis(cyclopentadienyl) compounds, cyclopentadienyl carbonyl compounds, bis(arene) compounds, arene carbonyl compounds; isolobal analogy, metal-metal bond, transition metal clusters; clusters and catalysis; hydride and dihydrogen complexes; fluxionality. **[15 hrs]**

UNIT-III

Organometallic Chemistry 3: Organometallic reactions and catalysis: oxidative addition, reductive elimination,insertion, hydride elimination, abstraction; olefin hydrogenation,hydroformylation, Wacker process, Ziegler-Natta polymerisation, cyclo oligomerisation, olefin isomerisation,olefin metathesis, Monsanto aceticacid synthesis, Fischer-Tropsch process, hydrosilylation. **[15 hrs]**

UNIT-IV

Organometallics in Organic Synthesis:-Bonding of Pd and Rh with olefins applications in C-C bond formations, Wacker reaction, Heck reaction, Carbonylation, hydroformylation, olefin

isomerism, arylation, aryl amination using Pd reagents,olefin metathesis, Stille coupling,Sonogashira reaction, Buchwald reaction and Pauson -Khand reaction. **[15 hrs]**

Reference Books:

1. P. Powell, Principles of Organometallic Chemistry, 2ndEdn. ELBS, 1991.
2. J. E. Huheey, Inorganic Chemistry, 3rdEdn. Harper International, 1983.
3. M. F. Purcell, J.C. Kotz, Inorganic Chemistry, Saunder, 1977.
4. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 5thEdn. JohnWiley.
5. R. W. Hay, Bio Inorganic Chemistry, Ellis Horwood, 1987.
6. R. M. Roat-Malone, Bio Inorganic Chemistry, John Wiley, 2002.
7. Clayden,J.; Greeves,N.;Warren,S., (2012).Organic Chemistry, Oxford University press, 2nd edition.

SEMESTER III: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH331	**16 Weeks**	**Solid state chemistry and advanced materials**	**3**	**1**	**0**	**4**

Course Objectives:

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

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

3. 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.

4. 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:

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

1. 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.
2. Reflecting and reviewing the principles of materials science (specifically microstructure design and selection) to the selection of materials for specific engineering applications.
3. 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.
4. Summarize and identify the similarities and differences among important classes of materials including glasses, metals, polymers, biomaterials, and semiconductors.

Course Outcomes	Program outcomes									
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	0	1	2	2	0	1	2
CO-2	2	2	2	2	3	2	2	2	1	2
CO-3	2	2	2	3	2	1	2	2	2	2
CO-4	2	2	3	2	3	2	2	2	1	3

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, Debye Sherrer 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; 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, p- n junction, super conductors, 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, Superconducting materials, Photoluminescent materials, Inorganic-organic hybrid materials, Porous materials. **[15 hrs]**

Reference Books:

1. A guide to laser in chemistry by 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 by John Walss 8. Electronic processes in materials: L. U. Azroff and J. J. Brophy

9. Chemistry of imperfect crystal: F. A. Krogen

10. Elements of X-ray Diffraction by B. D. Cullity, Addison- Weily.

11. Solid state Chemistry by A.R.West (Plenum)

12. Electronics made simple by Jacobwitz. Paper: PCH: 304 B: Advanced Chemical Kinetics (Elective)

SEMESTER III: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH341	16 Weeks	Structural Methods in Inorganic Chemistry	3	1	0	4

Course Objectives:

1. Structural methods in inorganic chemistry are used for locating flaws as well as for characterizing material properties.
2. Flaws within the materials can play havocs and may cause planes to crash, reactors to fail, trains to derail, pipelines to burst and alike.
3. Use of these techniques results in better confidence in the material and one may opt for lower value of factor of safety.
4. Obtaining the basic principles of various methods, nature of flaws, importance of NDT techniques, various applications of NDT techniques, limitations of NDT techniques, codes, standards and specifications related to non-destructive testing techniques etc. would be taught to the students and thus the students would have proper skills and would be equipped with proper competencies to locate a flaw in various materials, products.

Course outcomes:

CO-1: Demonstrate the knowledge of the basic concept of spectroscopy laser, optical spectroscopy, mechanism of fluorescence.

C0-2: Explore understanding of photoelectron spectroscopy (PES) and electron energy loss spectroscopy for chemical analysis and other most important applications.

C0-3: Create broad advanced techniques knowledge of SEM, SAM, SPM, STM, LEED, TEM, ASS and ICPMS for structure and chemical analysis applications.

C0-4: Acquire knowledge of non-destructive techniques for various metals, product analysis, effects and other applications.

Course outcome (COs)	Program outcomes (POs)										Program Scientific outcome (PSO)		
	PO 1	PO2	PO 3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO10	PSO1	PS02	PSO3
CO1	2	1	0	3	1	0	0	0	0	0	2	3	1
CO2	3	0	0	3	1	0	0	0	0	0	3	3	1
CO3	3	0	0	3	1	0	0	0	0	0	2	3	1
CO4	3	0	0	3	1	0	0	0	0	0	2	3	1

UNIT-I

Advanced optical spectroscopy: Overview of basic concepts: Light-matter interaction, Einstein coefficients, introduction to lasers, transition dipole moment, selection rules for electronic transitions, Jablonskii diagram, fluorescence and phosphorescence, kinetics of unimolecular and bimolecular processes.

Advanced concepts: Theory of nonradiative transitions, spin-orbit coupling and singlet-triplet transitions, polarized light absorption and emission: fluorescence anisotropy, solvation dynamics, energetics and dynamics of bimolecular processes like excimer and exciplex formation, resonance energy transfer, mechanisms of fluorescence quenching, introduction to non-linear spectroscopy.

Techniques and instrumentation: Steady-state fluorimetry, lasers as excitation sources, surface plasmon spectroscopy, multiphoton spectroscopy, single-molecule spectroscopy, fluorescence correlation spectroscopy. **[20 hrs]**

UNIT-II

Electron spectroscopy

Photoelectron spectroscopy: Electron energy analysis; photon sources -- UV, X-ray, synchrotron; vacuum - angular dependence - cross section and its determination; photoexcitation, valence and core photoemission, application in chemical analysis

Electron energy loss spectroscopy: Franck and Hertz experiment -- instrumentation -selection rules-theory - studies on molecules - surface states - high resolution spectroscopy - adsorption and catalysis – applications.

Imaging and Depth Profiling techniques: Basic concepts in surface imaging; secondary electron microscopy (SEM); secondary Auger microscopy (SAM); scanning probe microscopy (SPM); scanning tunneling microscopy (STM); transmission electron microscopy (TEM); low energy electron diffraction (LEED), surface imaging; depth profiling. Associated techniques of microscopy and spectroscopy.

[20 hrs]

UNIT-III

Non-destructive techniques: 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).

Destructive techniques: AAS, Inductively coupled plasma-atomic emission spectroscopy (ICP-AES).

Mossbauer spectroscopy: Theoretical basis. Interpretation of Mossbauer spectra-isomer shift-Quadrupole splitting and magnetic hyperfine structure, time and temperature effects. Instrumentation. Applications-structure deducetion-$I_2Br_2Cl_4$, $Fe_3(CO)_{12}$. **[20 hrs]**

Reference Books:

1. Modern Spectroscopy, J M Hollas, John Wiley & Sons, 4th Edn, 2004
2. Modern Optical Spectroscopy, William W Parson, Springer, Student Edn, 2009
3. Fundamentals of Photochemistry, K K Rohatgi-Mukhejee, Wiley Eastern Ltd, 1992
4. Principles of Fluorescence Spectroscopy, J R Lakowicz, Springer, 3rd Edn, 2006
5. Laser Spectroscopy- Basic concepts and instrumentation – W. Demtroder (Springer 3rd edition, 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. Catalytic Chemistry, B. Gates, Wiley, 1992.
11. Physical Chemistry of Surfaces, A.W. Adamson, A.P. Gast, Wiley, 1997.
12. Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age, 2008.
13. Introduction to Surface Chemistry and Catalysis, G.A. Somorjai, Y. Li , Wiley, 2010.
14. Physical chemistry of surfaces by Arthur W. Adamson 1990
15. The chemical physics of surfaces by Roy S. Morrison, S. Roy, 1990.
16. Modern techniques of surface science by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.
17. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, New York, 1993.

SEMESTER III: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH351	**16 Weeks**	**Advanced Inorganic chemistry**	**3**	**1**	**0**	**4**

Course Objectives:

1. Students able to 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.

2. To 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.
3. Discuss the Chemical processes on TM: ligand exchange, oxidative addition, reductive elimination, migratory insertion, nucleophilic attach on the ligand. Mechanisms and synthetic outcomes.
4. 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: Upon successful completion of this course, the student will be able to:

1. Knowledge of inorganic photochemistry, metal complexes in drugs, medicinal bioinorganic chemistry and advance nuclear chemistry.
2. Evaluating transition metal coordination compounds in terms of their geometry and interpret at a basic level their electronic properties.
3. Explain the Tabulate the coordination complexes undergoing a variety of reactions including electron transfer, ligand exchange and associative process.
4. Identifying the shapes and structure of coordination complexes with coordination numbers ranging from 4- 12.

Mapping of Course Outcomes with programme Outcomes

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO 1	2	1	3	3	2	2	0	0	1	2	3	3	2

	CO 2	4	3	2	2	2	1	0	0	1	2	3	3	2
	CO 3	2	2	0	3	3	1	0	0	1	2	3	3	3
	CO 4	4	3	1	2	2	1	0	0	1	2	4	3	3

UNIT – I

Inorganic Photochemistry: 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 chromium (III) complexes, Adamson's rules, photoactive excited states, V-C model – photo physics and photochemistry of ruthenium polypyridine complexes, emission and redox properties – photochemistry of organometallic compounds, metal carbonyl compounds, compounds with metal-metal bonding Reinecke's salt - chemical actinometer. **[15 hrs]**

UNIT-II

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

Treatment of toxicity due to inorganics: Mechanism of (i) Antidote complexes with poison, rendering it inert (heavy metals, iron, copper and thallium) (ii) Antidote accelerated metabolic conversion of poison to non-toxic product (cyanide). (iii) Antidote cometes with poison for essential receptors (carbon monoxide, morphine and morphine like narcotics). **[15 hrs]**

UNIT –III

Medicinal Bioinorganic Chemistry: Bioinorganic Chemistry of quintessentially toxic metals. Lead, Cadmium, Mercury, Aluminium, Chromium, Iron, Copper, Plutonium. Detoxification by metal chelation. 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 – Cytotoxic compounds of other metals – Gold containing drugs as anti-rheumatic agents and their mode of action - Lithium in Pschyco-pharmocological drugs. Radiopharmaceuticals – Technetium. **[15 hrs]**

UNIT – IV

Advanced Nuclear Chemistry: Radiochemical principles in the use of tracers - applications of radioisotopes as tracers - chemical investigations, analytical applications, agricultural and industrial applications - neutron activation analysis - carbon and rock dating - use of nuclear reactions - radioisotopes as source of electricity - nuclear medicines. Radiolysis of water and hydrated electron. **[15 hrs]**

Reference Books:

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

Semester-III – Inorganic chemistry practicals

Course Code	Duration	Course Title	L	T	P	C
MS17CH305	16 Weeks	Lab course in Inorganic chemistry	3	1	0	4

Course Objectives::

1. The practical course on Inorganic chemistry intends to provide the students scientific skills in qualitative and preparative techniques.
2. Appreciate the importance of being systematic in life.
3. 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:

1. Apply the practical knowledge in determination of strength of analyte.
2. Identify individual functional groups present in mixture of salt.
3. Detect the ions present in the sample by different techniques.
4. Estimate the amount of ions by volumetric and gravimetric methods.

Course Outcomes	Program outcomes									
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	3	2	2	2	3	2	2	0	1	2
CO-2	3	2	2	2	2	2	2	2	1	2
CO-3	2	2	2	3	2	1	2	2	2	2
CO-4	2	3	3	2	2	2	2	2	1	2

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.

PART – II

1. Preparation and characterization of:

a) Chloropentammine cobalt (III) chloride

b) Estimation of chloride in a complex by potentiometric or ion-exchange method

c) Record the electronic absorption spectrum of a complex and verify Tanabe Sugano diagram

2. Preparation of hexamine cobalt(III) chloride and estimate cobalt ion.
3. Determination of the composition of iron-phenanthroline complex by:

(a) Job's method

(b) mole-ratio method and

(c) slope-ratio method.

4. Preparation of tris(oxalate)ferrate(III) and estimate the metal ion.
5. Using chloropentamine cobalt(III) chloride, prepare nitro and nitritopentamine cobalt(III) chloride. Record the IR spectra of the isomers and interpret.
6. Estimate the chloride ion in a given complex by silver nitrate titration after ion- exchange separation.
7. 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

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 – Daniel C. Harris, (2006) 7th edition.
8. Spectrophotometric Determination of Elements – Z. Marczenko

ORGANIC CHEMISTRY

Course Code	Duration	Course Title	L	T	P	C
MS17CH102	16 Weeks	ORGANIC CHEMISTRY -1	3	1	0	4

Course objectives:

1. **Analyze the effect of conjugation, hyperconjugation delocalization, resonance and aromaticity in organic molecules**
2. **Identify the reactive intermediates in the reaction mechanism and also examine the rate of the reaction**
3. **Discuss the core concepts of stereochemistry in organic molecules**
4. **Explain the chemistry of carbohydrates, synthesis and biological importance of vitamins**

Course Outcome:

1. **Explain the effect of conjugation, hyperconjugation delocalization, resonance and aromaticity in organic molecules**
2. **Analyze the role of reactive intermediates such as carbocations, carbanion's carbenes nitrenes and kinetics during the course of reaction**
3. **Predict R/S, E/Z configuration, chirality in molecules by applying concepts of stereochemistry**
4. **Discuss the chemistry of carbohydrates, synthesis and biological importance of vitamins**

UNIT-1

Nature of Bonding in Organic Molecules: Delocalized chemical bonding: Conjugation, cross conjugation, resonance, Concepts of Aromaticity, non-aromaticity and antiaromaticity, NMR in aromatic Character. Aromaticity. Huckel's rule of aromaticity. Aromatic systems with electron numbers other than six (including azulene, tropone, tropolone and annulenes). Antiaromaticity. Aromaticity in benzenoids, meso-ionic compounds. Homo-aromaticity. Alternant and nonalternant hydrocarbons, Energy levels in odd and even-alternant hydrocarbons, energy levels

for the benzyl cation, benzyl free-radical and benzyl carbanion. Hyperconjugation. Tautomerism. **[15 hrs]**

UNIT-2

Reaction Mechanisms-I: Generation, structure, stability, and reactivity of carbocations, carbanions, carbon free radicals, carbenes and nitrenes. Classification of reactions and mechanisms. Thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates. Acids and bases: Hard and soft acids and bases. Effect of structure on the strengths of acids and bases.

Reaction Mechanisms-II: Effect of structure on reactivity:- Resonance and field effects; steric effects. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation. Nucleophilic substitution reaction at a saturated carbon: SN1, SN2, and SET mechanisms. Effect of substrate structure, attacking nucleophile, leaving group. Ambident nucleophiles and substrates. **[15 hrs]**

UNIT-3

Stereochemistry-Principles of stereochemistry: Conformational and Configuration isomerism in acyclic and cyclic compounds, stereoselectivity, enantioselectivity and diasterioselectivity, optical and geometrical isomerism. Fischer, Newman, Sawhorse and flying wedge projections and their interconversions.Optical isomerism: Elements of symmetry and chirality. D-L conventions. CIP rules, R-S and M-P conventions. Chirality in compounds with a stereogenic centre, and in allenes, alkylidene cycloalkanes and spiranes (with a stereogenic axis). Cram's and Prelog's rules. Conformational analysis: Conformational analysis of cycloalkanes: cyclobutane, cyclopentane, cychexanes (monosubstituted e.g., methyl, iso-propyl, tert-butyl and di-substituted cyclohexanes e.g., dialkyl, dihalo, diols), cycloheptane. **[15 hrs]**

UNIT-4

Carbohydrates: Introduction. Kiliani-Fischer synthesis, Determination of configuration of the monosaccharides, conformational analysis of monosaccharides. Synthesis of amino sugars (β-D-Glucosamine, galactosamine, N-acetylmuramic acid (NAMA), N-acetyl neuraminic acidNANA). C- and Nglycosides. Synthesis of aldonic, uronic, aldaric acids and alditols.Structure elucidation of sucrose and maltose.Structures of lactose, gentiobiose, and meliobiose. Photosynthesis of carbohydrates.

Vitamins

Biological importance and synthesis of Vitamin B1 (thiamine), Vitamin B6 (pyridoxine), folic acid, pantothenic acid, riboflavin, Vitamin H (biotin), Vitamins K1 and K2. **[15 hrs]**

Reference Books:

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 in Organic Chemistry, Peter Sykes, Longman, (2000).
4. Structure and mechanism of Organic Chemistry, C K Ingold, Cornell University Press (1999).
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, R O C Norman and J M Coxon, Blackie Academic and Professional, (1996).
8. Stereochemistry of Organic Compounds, D Nasipuri, New-Age International, (1999).
9. Stereochemistry of Carbon Compounds, E L Eliel, S H Wilen and L N Mander, John Wiley, (1994). 10. Stereochemistry, Potapov, MIR, Moscow, 1984.
11. Organic Chemistry, Volumes I and II, I L Finar, Longman, (1999)

Mapping CO- PO

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO1	PSO2	PSO3
C01	1	2	1	2	3	0	2	0	0	0	1	1	1
CO 2	1	3	0	2	3	0	0	0	0	0	1	2	2
CO 3	1	2	0	2	3	0	0	0	0	0	2	2	2
CO 4	1	2	1	0	3	0	0	0	0	1	1	3	2

SEMESTER –I - SOFTCORE (SC 1)

Course Code	Duration	Course Title	L	T	P	C
MS17CH125	16 Weeks	HETEROCYCLIC CHEMISTRY AND CHEMISTRY OF BIO-MOLECULES	3	1	0	4

Course objectives:

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 proteins structures.

iv. Discuss the topics include chemical and biochemical strategies used to elucidate natural product pathways.

Course outcomes:

After completion of the course students shall be able to:

1. Explain the fundamental concepts of reactivity and aromaticity of various heterocyclic compounds.
2. Illustrate the synthesis of various heterocyclic compounds.
3. Analyze the different types of heterocyclic compounds.
4. Outline the synthesis of prostaglandins-E1, E2 and vitamins.
5. Apply the biological importance of DNA, RNA and Classify the different types of proteins.

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO 1	1	2	3	3	3	2	0	0	1	3	3	2	2
	CO 2	1	2	3	1	3	3	2	1	2	2	2	2	2
	CO 3	1	3	2	2	2	1	0	0	1	2	1	2	2

	CO 4	1	3	2	2	3	1	1	1	1	2	2	2	2

UNIT-1

(a) **Small ring Heterocycles**-Three membered and four membered Heterocycles- synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxitanes, thietane,pyrrole,furan and thiophene.
b) **Benzo fused five membered Heterocycles** -Synthesis and reactions of benzopyrroles, benzofurans and benzothiophenes. **[15 hrs]**

UNIT-2

a) **Six membered Heterocycles with one heteroatom-** Synthesis and reactions of pyrilium salts and pyrones and their comparison pyridinium and thiopyrylium salts and pyridones. Synthesis and reactions of coumarins, chromones

b) **Six membered Heterocycles with two and more Heterocycles-**Synthesis and reactions of diazines & triazines

c) **Seven membered Heterocycles** -Synthesis and reactions of azepines, oxepines & thiepines. **[15 hrs]**

UNIT-3

Amino acids, Peptides and Proteins-Classification, general methods of preparation, properties and reactions of amino acids. Peptide bond; nomenclature and classification of peptides; Proteins: biological importance, classification based on structure and composition. General idea of the peptide linkage and primary structure of proteins and its determination; Sanger and Edman methods; Denaturation and renaturationthermal denaturation- aufinsens experiment with ribonuclease. Biosynthesis of peptides

Vitamins-Biological importance and synthesis of Vit A, Vit. B6, Vit C and Vit E (tocopherol). **[15 hrs]**

UNIT-4

Nucleic acids-Purine and pyrimidine bases. Structure of nucleosides and nucleotides. Methods of formation of internucleotide bonds (DCC, phosphotriester approach). Structure of DNA (Watson-Crick model) and RNAs. Biological importances of DNA and RNAs. Protein-nucleic acid interactionchromatin and viral nulear capsid.

Prostaglandins-General study, nomenclature, classification, structure and biological role of PGE1. PGE2 and PGE3. **[15 hrs]**

Reference Books:

1. Joule & Smith: Heterocyclic chemistry (Van Nostrand).
2. R. K. Bansal: Heterocyclic chemistry (Wiley E).
3. L. A. Paquitte: Principals of modern heterocyclic chemistry.
4. M. H. Palamer : The structure and reactions of heterocyclic compounds.
5. A. R. Katritzky: Advances in Heterocyclic chemistry (A.P.). 12. Finar: Organic chemistry (Vol. 1&2)
6. Biochemistry, J. David Rawn, Neil Pattuson publishers, North Carolina, (USA) 1989.

7. Organic Chemistry. Vol I and Vol II, I. L. Finar, 6th edn. 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.
Text book of Biochemistry, E. S. West, W. R. Todd, H. S. Mason & J. T. Van Bugen, 4th Edn. Amerind publishing co. (New Delhi), 1974.

SEMESTER-I: ORGANIC CHEMISTRY PRACTICALS

Course Code	Duration	Course Title	L	T	P	C
MS17CH106	16 Weeks	Lab course in Organic chemistry	0	1	3	3

Course objectives:

1. The practical course on organic chemistry intends to provide the students scientific skills in qualitative and preparative techniques. Appreciate the importance of being systematic in life.
2. It also helps to develop honesty, punctuality, analytical reasoning, questioning, critical evaluation and thinking among students.

Course outcome: Upon successful completion of this course, the student will be able to:

1. Acquire skill to perform common laboratory techniques, including reflux, distillation, steam distillation, re-crystallization, vacuum filtration and aqueous extraction
2. Evaluate data collected to determine the identity, purity, and yield of products
3. Characterize organic molecules by physical methods such as Melting point and boiling point.
4. Predict the outcome and mechanism of some simple organic reactions, using a basic understanding of the relative reactivity of functional groups

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
MS 17CH 106	CO 1	3	3	3	3	2	2	2	2	2	3	3	3	3
	CO 2	3	3	1	3	3	2	2	2	3	3	3	4	2
	CO 3	2	3	0	2	2	1	2	1	3	3	1	3	2
	CO 4	2	3	1	2	3	1	2	1	0	3	2	2	2

Preparation (one stage)

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.

Preparation (Two and three stages)

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.

Reference Books:

1. Manual of Organic Chemistry - Dey and Seetharaman.
2. Modern Experimental Organic Chemistry by John H. Miller and E.F. Neugil, p 289.
3. An Introduction to Practical Organic Chemistry - Robert, Wingrove etc.
4. A Text Book of Practical Organic Chemistry – A.I. Vogel.

SEMESTER -II: HARD CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH202	**16 Weeks**	**ORGANIC CHEMISTRY - II**	**3**	**1**	**0**	**4**

Course objectives: *This course is the continuation of Organic Chemistry-I,*

1. The course deals with the relationships between Organic chemical structures and their reactivity.

2. Studies of reaction mechanisms in addition, elimination, substitution, and rearrangement reactions.

3.To bring the knowledge of pericyclic, photochemical reactions and their mechanisms including the HOMO-LUMO concepts.

4. To motivate the student in solving the mechanisms of organic named reactions and molecular rearrangements.

Course Outcome: *After the completion of the course, the student will be able to,*

1. *Develop the knowledge of Mechanistic aspects of nucleophilic, electrophilic substitution and elimination reactions*
2. *Solve the problems based on pericyclic reactions and draw the HOMO-LUMO diagrams*
3. *Apply the concept of photochemistry in organic reaction and their mechanisms.*
4. *Analyse the mechanistic aspects in organic named reactions and molecular rearrangements.*

UNIT-1

Aromatic Substitution Reactions : Electrophilic Substitution Reactions: The arenium ion mechanism. Orientation and reactivity. Energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems.Quantitative treatment of reactivity in substrates and electrophiles.Effect of leaving group.Amination, sulfonylation reactions; Diazonium coupling, Vilsmeier-Haack reaction, Gatterman reaction, Gatterman-Koch reaction and Hoesch reaction.

Nucleophilic substitution reactions: The SNAr, SN1, benzyne and SRN1 mechanisms. Reactivity: effect of substrate structure, leaving group and attacking nucleophile. Goldberg reaction, Bucherer reaction, Schiemann reaction, von Richter reaction, Sommelet-Hauser and Smiles rearrangements.

Elimination Reactions: The E2, E1 and E1cB mechanisms and their spectrum.E2C and E2H mechanisms.Orientation of the double bond.Reactivity-effects of substrate structure, attacking base, the leaving group and the medium.Mechanism and orientation in pyrolytic elimination reactions (including Chugaev reaction). **[15 hrs]**

UNIT-2

Pericyclic Reactions: Introduction, Classification of pericyclic reactions, Electrocyclic reactions: con rotation and dis rotation. Electrocyclic closure and opening in 4n and 4n+2 systems.

Cycloaddition Reactions: suprafacial and antara facial additions in 4n and4n+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. Solving problems based on FMO approach. Conservation of orbital symmetry: (Correlation Diagrams) approach-for electrocylic and cycloadditions. **[15 hrs]**

UNIT-3

Photochemistry: **Photochemistry of π-π* Transitions**: Excited states of alkenes, cis-trans isomerisation, and photo stationary state. Photochemistry of 1,3-butadiene Electrocyclisation 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. Excited states of aromatic compounds-Photoisimerisation of benzene

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 diones. Norrish type II reactions in ketones, esters and 1,2 diketones, Addition to carbon-carbon multiple bonds, Paterno-Buchi reaction, Photochemistry of nitrites-Barton reaction. **[15 hrs]**

UNIT-4

Molecular Rearrangements and named reactions: Molecular rearrangements: Definition and classification. Molecular rearrangements involving 1) electron deficient carbon: Wagner- Meerwein, Pinacol-Pinacolone, Allylic and Wolf rearrangement. 2) electron deficient Nitrogen: Hofmann, Lossen, Curtius, Schmidt and Beckmann rearrangements 3) electron deficient Oxygen: Baeyer-Villiger oxidation. 4) Base catalysed rearrangements: Aldol condensation, Benzoin, Knoevengel, Perkin, Cannizaro, Benzilic acid, Favourski, Sommlett-Hauser and Smiles rearrangement.
Named reactions: ChiChibabin, mannich, Stark enamine, Click reaction, Mitsnobu recation, Pd catalyzed reactions–Suzuki, Heck reaction, still, Sonogashiro reaction. **[15 hrs]**

Reference Books:

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).
8. Photochemistry – J. G. Calverts and J. N. Pitts, John-Wiley & Sons
9. Fundamentals of Photochemistry- K. K. Rohatgi-Mukharjii, Wiley Eastern
10.Introduction to Photochemistry-Wells
11.Photochemistry of solutions-C. A. Parker, Elsevier

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
MS17CH202	CO1	3	2	0	2	2	2	0	0	0	1	3	2	1
	CO2	2	3	0	2	2	2	0	0	1	1	3	2	2
	CO3	3	3	1	2	2	1	0	0	0	1	3	2	2
	CO4	3	2	1	2	2	2	0	0	1	1	3	2	2

SEMESTER -II : SOFTCOFE

Course Code	Duration	Course Title	L	T	P	C
MS17CH225	**16 Weeks**	**SUPRAMOLECULAR AND MEDICINAL CHEMISTRY**	**3**	**1**	**0**	**4**

Course objectives:

The objective of the course is to provide

1. Provide knowledge on non-covalent bonding, and self-assembly.
2. Comprehend the working of working on cellular machinery such as the ribosomes, chaperone proteins and molecular recognitions.
3. Assimilate the intrinsic details of drug design, development and pharmacokinetics
4. Acquaint about the role of steroids and their role in various physiological process in humans.

Course outcomes:

By the completion of course student will be able to,

1. Explain the concepts of supramolecular chemistry.
2. Apply the knowledge of host - guest relationships in supramolecular complex.
3. Analyze the concepts of Pharmacokinetics and Structure-activity relationships for Drug Discovery.
4. Demonstrate the synthesis and applications of steroids.

Mapping of Course Outcomes with POs and PSOs

Course Code	POS / COs	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
M18CH225	**CO1**	2	1	2	1	2	1	1	0	0	1	2	1	2
	CO2	2	1	1	2	2	1	2	0	0	1	2	1	2
	CO3	2	1	2	1	1	2	2	0	0	1	2	1	2
	CO4	2	2	1	2	1	2	1	0	0	1	2	1	2

UNIT-1

Introduction: Concepts and development, Nature of binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, H-bonding, cation-π, anion-π, π-π and vander-waal interactions, Supramolecular Chemistry in Life, Ionophores, Porphyrin and other tetrapyrrollic macrocycles, Coenzymes, Neurotransmitters, DNA and biochemical self-assembly, Relevance of supramolecular chemistry to mimic biological system. **[15 hrs]**

UNIT-2

Host–guest Chemistry: Synthesis and structures of crown ethers, Lariat ethers, Podands, Cryptands, Spherands, Calixarene, Cyclodextrins, Cyclophanes, Cryptophanes, Carcerands and hemicarcerands, Host-guest interactions, Preorganisation and complimentarity, Lock and key analogy, Binding of cationic, Anionic, Ion pair and neutral guest molecules,Supramolecular Polymers: Self-assembly molecules: Design, Synthesis and Properties of the molecules, Self-assembly by H-bonding, Catenanes, Rotaxanes, Dendrimers and Supramolecular gels. **[15 hrs]**

UNIT-3

Pharmacokinetics, Pharmacodynamics, Theories of drug activity& Drug design: Basics of drug receptor interactions. Theories of drug activity. Hansch equation. Computer-aided drug design and molecular modeling.
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.

[15 hrs]

UNIT-4

Steroids- Synthesis of cholesterol, estrone, progesterone, androsterone, testosterone. Photo products of ergosterol- vitamins D. Barton reaction for the synthesis of aldosterone. Marker degradation. Brief discussion of homosteroids, norsteroids and oral contraceptives. Synthesis of (dl)-norgestrel and ethinyl oestradiol.Antibiotics-Structure elucidation and synthesis of streptomycin, penicillins, cephalosporin-C, chloromycetin and tetracyclins (terramycin and aureomycin). **[15 hrs]**

Reference Books:

1. Lehn, J. M., Supramolecular Chemistry-Concepts and Perspectives, Wiley –VCH (1995).

2. Beer, P.D., Gale, P. A., and Smith, D. K., Supramolecular Chemistry, Oxford University Press (1999). 3. Steed, J. W., and Atwood, J. L., Supramolecular Chemistry, Wiley (2000).

4. Burger's Medicinal Chemistry and Drug Discovery, Vols. 1-6 Ed. D.J. Abraham, John Wiley, 2003 2. Foye's

5. Principles of Medicinal Chemistry, 6th Edition T L Lemke and D A Williams Eds., Lippincott, Williams and Wilkins, 2007.

6. An Introduction to Medicinal Chemistry, P Graham, III Ed., Oxford, 2006 4. Medicinal Chemistry, N Weaver, Oxford, 2006.

7. Goodman and Gilman's Pharmacological Basis of Therapeutics, 11th Edition Tata McGraw-Hill, 2005.

8. The Organic Chemistry of Drug Design and Drug Action, R B Silverman, II Edition Academic Press, Amsterdam, 2004.

9. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical chemistry, J H Block and J M Beale, Jr., Eds., Lippincott, Williams and Wilkins, 2003.

10. Medicinal Chemistry – G R Chatwal, Himalaya, New Delhi, 2002

SEMESTER -III: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH342	**16 Weeks**	**ORGANOMETALLICS IN ORGANIC SYNTHESIS**	**3**	**1**	**0**	**4**

Course Objectives: This course aims to provide the student to:

1. 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
2. Evaluate the use of zirconium complexes in the synthesis of esters, iron complexes for the insertion of CO, cobalt complexes in the synthesis of ketones from epoxides.
3. Explain the Synthetic applications of tri methyl silyl chloride, Organo tin, Organo cerates, and Organo mercurial.
4. Develop and design the catalytic cycle for the Homogeneous and Heterogeneous catalysis.

Course Outcomes: Upon successful completion of this course, the student will be able to:

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

Course Outcomes	Program Outcomes												
	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**
CO-1	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**1**	**1**
CO-2	**2**	**1**	**2**	**0**	**3**	**1**	**2**	**2**	**0**	**0**	**2**	**2**	**2**

CO-3	**2**	**1**	**2**	**0**	**3**	**1**	**2**	**2**	**0**	**0**	**2**	**2**	**2**
CO-4	**2**	**1**	**1**	**0**	**2**	**1**	**1**	**2**	**0**	**0**	**2**	**1**	**1**

UNIT-1

Organometallic Compounds in Organic Synthesis-I: Chemistry of Organotransition metal complexes, General introduction. 18- and 16-Electron rules. General rules, Complexation and De-complexation Reactions: s-Bonded systems including h1 ligands. p- Bonded systems involving dihapto to octahapto ligands such as- olefins, acetylenes, allyl moieties, butadiene, cyclobutadiene, arenes, cyclopenta, cyclohexa and cycloheptadienyl moieties; cyclohepta, cyclooctatrienes, and cyclooctatetraene moieties. Use of organotransition metal complexes as protecting and stabilizing groups: Protection of olefins, acetylenes and dienes. Stabilization of cyclobutadines and norbornadienones. Organometallics as electrophiles and nucleophiles: Nucleophilic addition to h2, & h5 complexes. Electrophilic addition to h4, h6 and carbene complexes.
Organometallics in coupling and cyclization reactions: Coupling and cyclization of organic nucleophiles with olefins (including Heck reaction), and coupling of olefins with acetylenes (including Felkin's reaction).

[15 hrs]

UNIT-2

Organometallic Compounds in Organic Synthesis-II: Carbonylation reactions: Use of zirconium complexes in the synthesis of esters, acids, aldehydes or acyl halides from alkyl halides and in the hydroformylation of olefins and dienes. Use of iron complexes for the insertion of CO group into organic molecules such as dienes, alkyl halides, and vinyl epoxides. Use of cobalt complexes in the synthesis of ketones from epoxides, lactones from allylic alcohols and in the hydroformylation of olefins Use of palladium complexes for the carbonylation of alkyl halides, dienes and allenes.
Application of the following organometallics in Organic Synthesis
Organozincs: Preparation, reaction with compounds containing acidic protons, reaction with C-C multiple bonds, Simmons Smith, and Reformatsky reaction.
Organolithiums: Preparation. Deprotonation reactions, nucleophilic addition reactions, reactions with imines, nitriles and isonitriles.
Organocopper reagents: (Gilman reagents-lithium dialkyl cuprates): Preparation, reactions with alkyl, allyl, vinyl, benzyl and aryl halides, aldehydes, ketones (including a,b-unsaturated carbonyl compounds) and epoxides. **[15 hrs]**

UNIT-3

Organoseleniums: Preparation. Use of organoseleniums in the synthesis of alkenes fromalkyl halides, α,β -unsaturated carbonyl compounds from carbonyl compounds.

Organotelluriums: Debromination of vic-dibromides, deoxygenation of epoxides, oxidation of hydroquinone and synthesis of biaryls. Organoaluminiums: Preparation, hydroalumination and carboalumination of alkenes.

Organometallic Compounds in Organic Synthesis-III

Organosilicons: Introduction, preparation and general reactions of trialkylsilyl halides. Peterson olefination Organotins: Preparation and reactions of tri-n-butyltin hydride, Barton decarboxylation and Barton-McCombie reaction Organocerates: Preparation and reactions of organocerates Organomercurials: Preparation. Electrophilic substitution reactions. Solvomercuration-demercuration and cyclopropanation of alkenes. **[15 hrs]**

UNIT-4

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. Monsanto L-Dopa synthesis, water gas shift reaction, carbonylation, template synthesis, alkene hydrosilation.

Herterogeneous Catalysis: Introduction, Fischer-Tropsch reaction, Ziegler-Natta catalysis **Biological applications** and environmental aspects of organometallic compounds: Introduction, organometallics in medicine, agriculture, horticulture and environmental aspects **[15 hrs]**

Reference Books:

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, H. O. House, W.A. Benjamin, California, 2nd Edn. 1972.
6.Organometallics, Vol. 1 & 2, M. Bochmann, Oxford Chemistry primers, Oxford University Press, 1994.
7. Advanced Organic Chemistry, J. March, 4th Edn. John Wiley, 2008.
8. Organo-transition metal chemistry, S. G. Davies, Pergamon Press, Oxford, 1982
9.Inorganic Chemistry - F.A. Cotton and G. Wilkinson (2nd edn).
10. Inorganic Chemistry Principles and Structure –J. Huheey.
11.Fundamental Transition metal Organometallic Chemistry – Charles M. Lukehart.
12.Inorganic chemistry- Purcell and Kotz. 6. J. March, Advanced Organic Chemistry, Willey Interscience, 1994.
13. Comprehensive Organic Synthesis, – Trost series, Pergamon Press, New York, Vol. 1, 1991. 8. R. Norman and J. M. Coxon, Principles of organic synthesis, 2nd edition, Replika Press Pvt. Ltd., India, 2005.

SEMESTER -III : SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH312	**16 Weeks**	**ADVANCED ORGANIC CHEMISTRY**	**3**	**1**	**0**	**4**

Course Objectives:

1. Explore the structure and reactivity of organic molecules with emphasis on reaction mechanisms.

2. Examine the principles of bonding, stereochemistry, kinetics and thermodynamics in organic synthesis.

3. Evaluate the logical disconnections to identify the synthons and choose the reactants and reagents.

4 Explore the feasibility of a process in terms of cost, conditions and availability of the starting materials.

Course Outcomes for the subject:

By the completion of course, the student will be able to,

1. Apply the knowledge of organic reactions and identify the retrosynthetic paths for planning organic synthesis.
2. Evaluate the relevance of reaction methodology and examine the conditions and reagents for carbon - carbon and carbon-heteroatom bond formation.
3. Enhance the understanding of organic mechanisms and interpret the selectivity of organic reactions
4. Analyze the underlying factors governing chemical reactions and demonstrate the synthetic strategies

Mapping of Course Outcomes with Pos and PSOs

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
M18CH312	CO1	3	1	2	1	2	3	1	0	0	1	2	1	2
	CO2	2	1	2	2	2	1	2	0	0	1	2	2	3
	CO3	2	2	1	1	3	2	3	0	0	1	3	1	2
	CO4	3	2	2	1	2	1	2	0	0	1	2	2	3

UNIT-1

Introduction to Disconnection approach- basic Principle: Synthesis of Aromatic Compounds, strategy I: The order of Events, One-Group C-X Disconnections, Strategy II: Chemoselectivity, Strategy III: Reversal of Polarity, Cyclisation Reactions, Amine Synthesis, Strategy IV: Protecting Groups ,One-Group C-C Disconnections I: Alcohols, General Strategy A:Choosing a Disconnection, Strategy V:Stereoselectivity.

[15hrs]

UNIT-2

One -Group C-C Disconnections II: Carbonyl Compounds, Strategy VI: Regioselectivity, Alkene Synthesis, Strategy VII : Use of Acetylenes , Two- Group Disconnection I: Diels-Alder Reaction, Strategy VIII: Introduction to Carbonyl Condensations, Two-Group Disconnection II:1,3-Difunctionalised compounds, α,β- unsaturated Carbonyl compounds. Strategy IX: Control in carbonyl compounds.

[15hrs]

UNIT-3

Two Group disconnection III: 1,5-difunctionalised Compounds, Micheal Additions and Robinson Annelation, Strategy X: Use of Aliphatic, Nitro Compounds in Synthesis, Two- group Disconnection IV: 1,2-Difuntionalised compounds, strategy XI: Radical Reactions in the Synthesis, FGA and its Reverse, Two-Group Disconnection V: 1,4-Difunctionalised compounds, Strategy XII: Reconnections, Two-Group Disconnection VI: 1,6-Difunctionalised compounds, General Strategy B:Strategy of Carbonyl

Disconnections, Strategy XIII: Introduction to Ring Synthesis, Saturated Heterocycles .Three-Membered Rings. **[15hrs]**

UNIT-4

Strategy XIV: Rearrangements in Synthesis, Four-Membered Rings: Photochemistry in synthesis, Strategy XV: Use of ketenes in synthesis, Five-Membered Rings, Strategy XVI: Pericyclic Rearrangements in synthesis, Six-Membered Rings, General Strategy C:Strategy of Ring Synthesis, Strategy XVII: Stereoselectivity B, Aromatic Heterocycles, General Strategy D: Advanced Strategy.

[15hrs]

Reference Books:

1. Organic synthesis: The synthon approach, S. Warren, John Wiley & Sons, New York, 1st. Edn. 1983.
2. Advanced organic chemistry, J. March, 4th Edn. John Wiley, 2008.
3. Organic Chemistry, R. E. Ireland Prentice-Hall India, New Delhi, 1975.
4. Some modern methods of Organic Synthesis, W. Caruthers, Cambridge Uni. Press London, 2nd Edn., 1998.
5. Designing organic synthesis: A disconnection approach, S. Warren, John Wiley & Sons, New York, 2nd Edn. 1987.
6. Carruthers. W., Some Modern Methods of Organic Synthesis, Cambridge University Press (1987)
7. Sanyal, S.N.,Reactions, Reaarangements &Reagents, Bharati Bhavan (2004)
8. Chemistry Education: Research and Practise in Europe, 2002, Vol.3, No.1, pp.33-64
9. Organic synthesis, C. Willis and M. Wills, Oxford University Press, 1995.
10. Organic synthesis: Concepts, methods and starting materials, J. Furhfop and G. Penzillin, Verlag VCH.
11. Principles of organic synthesis, R. Norman and J. M. Coxon, Blackie Academic & Professional
12. Advanced organic chemistry Part B, F. A. Carrey and J. Sundberg, Plenum Press, 1999.
13. Organic chemistry Vol. 2, 6th Edn., I. L. Finar, Longman, 1992.

SEMESTER -III : SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH322	16 Weeks	ADVANCED ORGANIC SYNTHESIS	3	1	0	4

Course Objectives:

1. It deals with the relationships between Organic chemical structures and their reactivity.
2. Focuses on studies of reaction mechanisms in addition, elimination, substitution reactions
3. To bring the importance of mechanism in C-C and C-N containing organic compounds and rearrangement reactions
4. To identify the suitable regent for organic reaction and to determine their reaction mechanisms.
5. To study the concept of enantiomeric excess and the importance of asymmetric synthesis.

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

1. Analyze functional groups effect on electron density, properties and reactivity in organic compound.
2. Utilize the principles behind enantioselectivity and diastereoselective in organic synthesis.

3. Explain the reaction mechanism involved in organic named reactions with respect to C-C and C-N bonding
4. Identify and inspect the mechanisms involved in named reactions, reagents, oxidations and reductions in solving chemistry problems.

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
MS 17CH322	**CO 1**	**3**	**2**	**0**	**2**	**2**	**2**	**0**	**0**	**1**	**1**	**3**	**2**	**1**
	CO 2	**3**	**3**	**1**	**2**	**2**	**2**	**0**	**0**	**1**	**1**	**3**	**2**	**2**
	CO 3	**3**	**3**	**1**	**2**	**2**	**1**	**0**	**0**	**1**	**1**	**3**	**2**	**2**
	CO 4	**2**	**2**	**1**	**2**	**2**	**2**	**0**	**0**	**1**	**1**	**3**	**2**	**2**

UNIT-1

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

UNIT-2

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

Oxidations-I :Cr (VI) oxidants, Mn (VII) oxidants, OsO_4, SeO_2, Pb $(OAc)_4$, HIO_4, Ag_2O, DMSO.

[15hrs]

UNIT-3

Oxidations-II, ozone, peroxides (H_2O_2, t-BuOOH, dibenzoylperoxide) and peracids (Preparation, properties and applications of CF_3COOOH, m-CPBA, momoperphthalic acid) as oxidizing agents. Dess-Martin oxidation.

Reductions, Complex metal hydrides, dissolving metal reductions (including Birch, Benkeser, Clemmensen reductions), diimide reduction, catalytic hydrogenation (homogeneous and heterogeneous), organoboranes as reducing agents. Wolf-Kishner reduction, McMurry reaction. Pummer, Willgerdot, Corey-Bakshi-Shibata and Tishchenko reactions. **[15hrs]**

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 1,4asymmetric induction). Asymmetric aldol condensation. Addition of allylmetal and allylboranes 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, (-)- iBOAlCl2, alpine-borane, (S)-BINAL-H, (R,R)-DIOP, and (S,S)-CHIRAPHOS). Enantioselective alkylation of ketones via hydrazones. Enantioselective alkylation with chiral PTC. Enantioselective Michael addition. Enantioselective intramolecular aldol condensation. Use of (+)- and (–)- DET in asymmetric epoxidation. Polymer-bound chiral catalysts in asymmetric induction. Asymmetric amplification. **[15hrs]**

References

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

SEMESTER -III : SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH332	16 Weeks	NATURAL PRODUCTS	3	1	0	4

Course objectives:

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

Course Outcomes:

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

1. Acquire the knowledge of Identifying and Characterizing various classes of natural products by their structure Appreciate the biogenesis of many natural products of importance.
2.Contribute the knowledge of natural products in drug design and development of new drugs with hemisynthetic routes or with total synthesis.
3. Discuss the use of natural products as starting materials for medicine.
4. Carry out independent investigations of plant materials and natural products.

UNIT-1

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, □-santonin and gibberrillic acid.

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. **[15hrs]**

UNIT-2

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, reserpine and ergotamine.

Photochemical synthesis of Nuciferine, coradyline and tylophorine.

[15hrs]

UNIT-3

Porphyrins and vitamin B_{12}: Structure elucidation and synthesis of haemin, chlorophyll-a and vitamin-B12 (synthesis of Vitamin-B12 from cobyric acid).

Nucleic acids: Introduction, components of nucleic acids, nucleosides, nucleotides and oligonucleotides. Structure elucidation and synthesis of nucleosides and nucleotides. Chemical synthesis of oligonucleotides: Protecting groups for hydroxy group in sugar, amino group in the base and phosphate functions. Methods of formation of internucleotide bonds: DCC, phosphodiester approach, phosphotriester approach, phosphite triester and phosphoramidite methods. Solid phase synthesis of oligonucleotides.

[15hrs]

UNIT-4

Prostaglandins: Introduction, nomenclature, classification and biological role of prostaglandins. Structure elucidation and stereochemistry of PGE1, PGE2 and PGE3. Synthesis of PGE1 and PGE2 by Corey's and Stork's approaches. Synthesis of PGE3 by Upjohn's approach. Synthesis of prostacyclin I2 and thromboxane B_2. Biosynthesis of prostaglandins.

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).

[15hrs]

Reference Books:

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, 6th Edn. Longman, 1992.
8.Chemistry of natural products Vol. I & II, O. P. Aggarwal, Goel Publishing House, 6th Edn. 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.

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
MS17 CH332	CO1	3	2	0	1	2	0	0	0	1	1	3	2	2
	CO2	3	2	3	3	2	0	0	0	1	1	3	2	2
	CO3	2	2	3	2	2	0	0	0	1	1	3	2	1
	CO4	2	2	2	2	3	2	0	0	1	1	3	2	2

SEMESTER -III : SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH352	16 Weeks	GREEN CHEMISTRY	3	1	0	4

Course objectives: This course offers the following concepts for students;

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

Course Outcome: After the completion of this course, students 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 Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO1	2	2	1	2	1	2	0	1	0	0	2	2	1

	CO2	3	1	2	2	2	3	0	2	0	0	2	1	2
	CO3	2	3	2	1	2	2	0	2	0	0	1	2	3
	CO4	3	2	2	1	2	1	0	2	0	0	2	2	3

UNIT-1

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.

UNIT-2

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. **[15hrs]**

UNIT-3

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.

UNIT-4

Supported catalyst and Bio-catalyst for Green chemistry

Introduction-the concept of atom economy-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.

Reference Books:

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

SEMESTER III – Organic and Physical chemistry

Course Code	Duration	Course Title	L	T	P	C
MS17CH306	16 Weeks	LAB COURSE IN ORGANIC AND PHYSICAL CHEMISTRY	0	1	3	3

Course Objectives:

1. The practical course on organic and physical chemistry intends to provide the students scientific skills in qualitative and preparative techniques.
2. Bring the knowledge of handling the chemicals and their identification through chemical analysis.
3. Appreciate the importance of being systematic in life.
4. Also helps to develop honesty, punctuality, analytical reasoning, questioning, critical evaluation and thinking among students.

Course Outcomes:

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

6. Acquire skill to perform chemical reaction, common laboratory techniques, including reflux, distillation, steam distillation, re-crystallization, vacuum filtration and aqueous extraction.
7. Calculate a limiting reagent and percent yield.
8. Evaluate data collected to determine the identity, purity, and yield of products, and also able to characterize organic molecules by physical methods such as Melting point and boiling point.
9. Predict the outcome and mechanism of some simple organic reactions, using a basic understanding of the relative reactivity of functional groups

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
MS17 CH306	CO1	3	2	1	3	2	0	3	0	0	1	3	3	2
	CO2	2	2	1	3	1	1	1	0	3	1	3	2	2
	CO3	2	2	2	3	2	2	2	0	2	1	3	2	2
	CO4	2	2	1	1	2	1	0	0	0	1	3	2	1

Organic Chemistry Practicals - II

Qualitative analysis Systematic analysis and identification of organic compounds

Physical Chemistry Practicals - II

1. To study the kinetics of reaction between acetone and iodine - determination of order of reaction w.r.t. iodine and acetone.

2. Determination of mean ionic activity coefficient of a weak electrolyte (acetic acid) by conductometric measurements.

3. Potentiometric titration of $Pb(NO_3)_2$ *vs* EDTA.

4. Preparation of Ag/AgCl electrode and to determine the activity of 0.2M HCl.

5. To determine the eutectic point of a two component system (Naphthalene-biphenyl system).

6. Conductometric method of determination of solubility of sparingly soluble salt.

7. Study of *p*H effect (by inhibitors) on electrochemical dissolution of a metal.

8. Determination of *p*K value of an indicator (methyl orange).

9. Spectrophotometric analysis of a mixture of (a) $KMnO_4$ and $K_2Cr_2O_7$.

10. To study the kinetics of saponification of ethyl acetate by conductivity method, determination of order of reaction w.r.t. $[OH^-]$.

11. To study the kinetics of reaction between acetone and iodine-determination of order of reaction w.r.t. iodine and H_2SO_4.

12. Kinetics of decomposition of benzene diazonium chloride, determination of energy of activation and thermodynamic parameters.

13. Determination of ionic product of water and study the effect of temperature by conductivity method.

14.Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal

15.Verification of Beer-Lambert law using gold/silver nanoparticles

16. Determination of pKa of a weak organic acid or a base using UV-Vis spectrophotometry

17. Determination of stability constant of metal-ligand complexes by spectrophotometric method – Fe^{II}-(1, 10-phenantroline)complex

18. Determination of stability constant of metal-ligand complexes by ny pH-metric methods – Cu^{II}-glycinate, Cu^{II}- sulfosalicylate complexes

PHYSICAL CHEMISTRY

SEMESTER I - HARD CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH103	**16 Weeks**	**Physical Chemistry I**	**3**	**1**	**0**	**4**

CHEMICAL THERMODYNAMICS, STATISTICAL THERMODYNAMICS, CHEMICAL KINETICS AND ELECTROCHEMISTRY

Course objectives: This course aims to provide the student to

a. Correlate the basic concepts of Thermodynamics in the in the day to day life and in the industrial perspective.

b. Illustrate the quantum statistical methods that uses molecular properties to predict the behavior of macroscopic quantities of compounds.

c. Conclude the theories of chemical kinetics and study the reactions with advanced flow techniques.

d. Design the electrode and electrolyte systems by the electrode kinetics using the basic knowledge of the electrochemistry

Course Outcomes: On successful completion of the course students shall 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 Outcomes	Program Outcomes												
	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
CO-1	1	0	0	0	0	1	0	0	1	2	2	0	0
CO-2	0	0	0	0	0	1	0	0	1	2	1	0	0
CO-3	1	0	0	0	1	1	1	1	2	2	2	0	1
CO-4	1	0	0	0	1	1	1	1	2	2	2	0	2

UNIT – I

Thermodynamics: Brief overview of thermodynamic laws, Concepts of entropy and free energy. 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

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-efficients by vapour 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: 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

Kinetics: Theory of reaction rates, kinetics of complex reactions, Parallel, consecutive and reversible reactions. Determination of order of reaction. Arrhenius equation, 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

Electrochemistry: Derivation of Nernst equation, Mobility and conductivity of electrolytes, Arrhenius theory of strong and weak electrolytes and its limitations, Concept of activity and activity coefficents in electrolytes, Debye-Huckel theory of strong electrolytes, Debye Huckel-Onsager equation, Debye-Huckel limiting equation for activity co-efficients, Debye-Huckel equation for appreciable concentrations. 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. True and apparent transport numbers. Abnormal transport numbers, effect of temperature and concentration on transport number.

Irreversible electrode process: Introduction, reversible and irreversible electrodes, reversible and irreversible cells. Electrode and cell potentials, Polarization, over voltage - ohmic over voltage, concentration over voltage activation over voltage, experimental determination of over voltage., decomposition potential Equations for concentration over potential, diffusion current – stationary current, potential curves, thickness of diffusion layer, diffusion controlled current – potential curves at a dropping mercury electrode, polarography, half wave potential, application in qualitative and quantitative analysis. Energy barrier and electrode kinetics, Butler-Volmer equation, Tafel equation. Hydrogen over voltage

[15 hrs]

Reference Books:

1. Thermodynamics for Chemists by S. Glasstone, Affiliated East-West Press, New Delhi, (1965).
2. Chemical Thermodynamics by I.M. Klotz, W.A. Benzamin Inc. New York, Amsterdam (1964).
3. Basic Physical Chemistry by W.J. Moore, Prentice Hall of India Pvt. Ltd., New Delhi (1986).
4. Text Book of Physical Chemistry by Samuel Glasstone, MacMillan Indian Ltd., 2nd edition (1974).
5. Theoretical Chemistry by S. Glasstone.
6. Elementary Statistical Thermodynamics by N.D. Smith Plenum Press, NY (1982).
7. Elements of Physical Chemistry by Lewis and Glasstone.
8. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990)
9. Chemical Kinetics by K.J. Laidler.
10. Chemical Kinetics by Frost and Pearson.
11. Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.

12. Chemical Kinetics by L.K. Jain.
13. Chemical Kinetics by Benson.
14. Kinetics in Analytical Chemistry by H.B. Mark and G.A. Rechnitz, Wiley Interscience Publishers, John Wiley and Sons, New York.
15. Introduction to Electrochemistry by S. Glasstone.
16. Statistical Themodynamics by B.C. Meclelland, Chapman and Hall, London (1973).
17. Elementary Statistical Thermodynamics by N.D. Smith, Plenum Press, NY (1982).
18. Elements of Classical and Statistical Thermodynamics by L.K. Nash, Addison- Wesley(1970).
19. Statistical Thermodynamics by I.M. Klotz.

SEMESTER -I: SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH135	**16 Weeks**	**Surface, Interface and Catalysis**	**3**	**1**	**0**	**4**

Course Objectives: This course on Advances in surface, interface and Catalysis,

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:

After successful completion of the course students shall be able to

1. Acquire the knowledge of Suface forces, surface energy, Electrostatic forces, Electrical double layer, Solid surfaces, structures.
2. Explain the Fundamental processes in catalysis, Structures, Kinetic aspects Heterogenous catalysts, Bio enzyme catalysis.

3. Synthesize the metal oxide catalysts, catalysis by porous materials.
4. Identify the Photocatalysts, Electro catalysts.

Mapping of Course Outcomes with programme Outcomes (sample)

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO 1	3	3	1	0	2	1	0	0	0	2	2	4	3
	CO 2	4	3	3	2	3	3	0	0	1	2	3	4	2
	CO 3	2	1	3	3	3	2	0	0	1	2	3	4	3
	CO 4	1	3	3	2	3	3	0	0	1	2	2	4	2

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. Dynamics and energetics of surfaces. Adsorption from solution and gas on surface, 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. **[20 hr]**

UNIT – II

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 heterogenous catalytic processes. **[20 hr]**

UNIT – III

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.

[20 hr]

Reference Books:

1.A. Zangwill, Physics at Surfaces, Cambridge Univ. Press, 1988.

2.B. Gates, Catalytic Chemistry, Wiley, 1992.

3.A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces, Wiley, 1997.

4.J. M. Thomas and W.J. Thomas, Principles and Practice of Heterogeneous Catalysis, Wiley-VCH, 1997.

5.K.W. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience, Wiley, 2002.

6.D.K. Chakrabarty and B. Viswanathan, Heterogeneous Catalysis, New Age, 2008.

7.G.A. Somorjai, Y. Li , Introduction to Surface Chemistry and Catalysis, Wiley, 2010.

8.Physical chemistry of surfaces by Arthur W. Adamson 1990

9.Chemical kinetics and catalysis by R.I. Masel, Wiley-Interscience, 2001.

10.The chemical physics of surfaces by 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 by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.

13.Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, New York, 1993.

SEMESTER I – Physical Chemistry Lab

Course Code	Duration	Course Title	L	T	P	C
MS17CH107	16 Weeks	Lab course in Physical chemistry - I	0	1	3	3

Course Objectives: The practical course on physical chemistry intends to provide the students;

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

Course outcomes: After the completion of this course, students able to

CO1: Operate instruments during conduction of experiments.

CO2: Analyze and interpret the experimental data.

CO3: Demonstrate experimental skills in laboratories.

CO4: Identify causes for erratic results and achieve better results.

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO1	1	2	1	2	1	2	0	2	0	0	2	2	2
	CO2	2	1	2	2	2	1	0	2	0	0	1	2	1
	CO3	2	2	2	1	1	2	0	1	0	0	2	1	2
	CO4	2	2	2	2	2	2	0	2	0	0	2	0	0

Kinetics

1. Study of kinetics of hydrolysis of an ester using HCl/H_2SO_4 at two different temperatures, determination of rate constants and energy of activation.

2. Study of kinetics of reaction between $K_2S_2O_8$ and KI, first order, determination of rate constants at two different temperatures and *E*a.

3. Determination of energy of activation for the bromide-bromate reaction.

4. Study of kinetics of hydrolysis of an ester using HCl/H_2SO_4 at two different concentrations, determination of rate constants and compare the rate constants.

5. Study of kinetics of reaction between $K_2S_2O_8$ and KI, second order, determination of rate constant and *E*a.

6. Kinetics of photodegradation of indigocarmine (IC) using ZnO as photocatalyst andstudy the effect of [ZnO] and [IC] on the rate of photo degradation.

7. To study the salt effect on kinetics of reaction between $K_2S_2O_8$ and KI.

8. Kinetics of acid hydrolysis of an ester and study of effect of dielectric constant of the medium (using CH_3OH).

9. Studies of kinetics of autocatalytic reaction of $KMnO_4$ vs Oxalic acid

Conductometry

1. Conductometric titration of a mixture of HCl, CH_3COOH and $CuSO_4$ against NaOH.
2. To determine the degree of hydrolysis and hydrolysis constant of aniline hydrochloride.
3. Conductometric titration of sodium sulphate against barium chloride
4. Conductometric titration of a mixture of HCl and $ClCH_2COOH$ against NaOH.
5. Conductometric titration of formic acid/oxalic acid against NaOH and NH_4OH.
6. Conductometric titration of orthophosphoric acid against NaOH.

Potentiometry

1. Potentiometric titration of KI *vs* $KMnO_4$ solution.
2. Potentiometric titration of KCl *vs* $KMnO_4$ solution.
3. Potentiometric titration of Fe(II) vs V(V).
4. Potentiometric titration of Fe(II) *vs* Ce(IV).
5. Potentiometric titration of a mixture of halides (KCl+KBr) against $AgNO_3$.
6. Potentiometric titration of $AgNO_3$*vs* KCl.
7. Determination of redox potential of Fe^{2+} ions by potentiometric method.
8. Determine the concentration of KI potentiometrically by calibration method
9. Determination of dissociation constant of a weak acid by potentiometric method.
10. Determination of single electrode potential

pH

1. Preparation of phosphate buffer
2. Calibration of pH meter and pKa measurements

Spectrophotometry

1. To obtain the absorption spectra of coloured complexes, verification of Beer's law and estimation of metal ions in solution using a spectrophotometer.
2. Spectrophotometric titration of $FeSO_4$ against $KMnO_4$.
3. Verification of Beer's law and calculation of molar extinction coefficient for $CuSO_4$system.
4. Spectrophotometric titration of $FeSO_4$ against $K_2Cr_2O_7$.
5. Study of kinetics of reaction between CAT and indigocarmine spectrophotometrically and determination of rate constant

Viscosity

1. Determination of the molecular weight of a polymer material by viscosity measurements (cellulose acetate/methyl acrylate).
2. Determination of the molecular weight of a polymer material by viscosity measurements (polyvinyl alcohol/polystyrene).
3. Binary analysis of two miscible liquids by viscometric method (Ethanol & Water)

Refractive index

1. Analysis of a binary mixture (Gylcerol & Water) by measurement of refractive index.

Distribution

1. Distribution of I_2 between hexane/cyclohexane and aqueous KI solution – calculation of equilibrium constant
2. Distribution of Acetic acid between n-butanol and water

Adsorption

1. Adsorption of acetic acid on charcoal and silica gel

Reference Books:

1. Practical Physical Chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels *et al*.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico-Chemical Experiments – J. Rose.

7. Practical Physical Chemistry – S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994).
11. Experimental Physical Chemistry – R.C. Das and B. Behera, Tata Mc Graw Hill.

SEMESTER II - HARD CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH203	16 Weeks	Physical Chemistry II	3	1	0	4

Course objectives:

This course on physical chemistry,

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:

On successful completion of course students shall be able to:

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

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

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

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

ourse Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PO9	PO 10	PSO 1	PSO 2	PSO 3
	CO 1	2	3	2	2	2	1	0	0	1	1	2	2	2
	CO 2	2	3	1	2	2	2	0	0	1	3	2	1	3
	CO 3	2	3	2	2	3	1	0	0	2	3	2	2	2
	CO 4	3	3	2	2	3	2	0	0	1	2	3	2	3

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, turn over rule, atomic units. Wave equation for stretched strings, Schrodinger wave equation for particles, Eigen values and Eigen functions, postulates of quantum mechanics. Application of Schrodinger equation to a free particle and to a particle trapped in a potential field (one dimension and three dimensions). Degeneracy, Wave equation for H-atom, Physical interperation of wave function, separation and solution of R, ϕ and θ equations. 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 correction, application to He-atom (first order correction only) –

calculation of first ionization potential and binding energy. Variation theorem: statement and proof.

[15 hrs]

UNIT – II

Molecular symmetry: Symmetry elements and symmetry operations, rotation axis, rules for orientation of molecules, plane of symmetry, rotation-reflection axis, centre of symmetry and identity element of symmetry. Products of symmetry operations. General relations among symmetry elements and symmetry operations.

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, D_2h and C_3v, D_3h).

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. **[15 hrs]**

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. Stark effect in rotation spectra and 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.

[15 hrs]

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, spin-spin splitting, high resolution NMR spectra of simple molecules, first and second order treatment of AB systems - FT techniques.

Other Resonance Spectroscopy Methods:- EPR, Electron spin resonance: g value, hyperfine structure, ESR of organic free radicals, ESR of solids, ESR of inorganic ions, ESR of simple free radicals in solutions. **[15 hrs]**

Reference Books:

1. Elements of Physical Chemistry – Lewis and Glasstone.
2. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990).
3. Basic Physical Chemistry by W.J. Moore, Prentice Hall, New Delhi, (1986).
4. Physical Chemistry – G.M. Barrow, McGraw Hill International Service (1988).
5. Quantum Chemistry – A.K. Chandra. 2nd edition, Tata McGraw Hill Publishing Co. Ltd., (1983).
6.. Quantum Chemistry – Eyring, Walter and Kimball. 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).
10. Valence Theory – Tedder, Murel and Kettle.
11. Quantum Chemistry – D.A. McQuarrie.
12. Theoretical Inorganic Chemistry – Day and Selbin.

13. Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash. 4th edition, Tata McGraw Hill, New Delhi.

14. Introduction to Spectroscopy - Pavia, Lampman and Kriz, 3rd edition, Thomson.

15. Spectroscopy, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York, Vol. 1 and 2, 1976.

16. Vibration Spectroscopy Theory and Applications, D.N. Satyanarayana, New Age International, New Delhi.

SEMESTER II - SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH235	16 Weeks	Advanced Chemical Kinetics and Thermodynamics	3	1	0	4

Course objectives:

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1. To acquire knowledge about the the kinetics of unimolecular and bimolecular photophysical and photochemical processes.
2. To provide the student with principles and kinetic tools useful in analyzing the rates of chemical reactions for both homogeneous and heterogenous reactions.
3. To present a comprehensive and rigorous treatment of classical thermodynamics.
4. To understand the innate details of advanced solution thermodynamics.

Course outcomes:

By the completion of course student will be able to,

1. Analyze the theories of reaction rates; assess the kinetics of unimolecular and bimolecular photophysical and photochemical processes.
2. Distinguish the activation and diffusion-controlled process; evaluate the different types of overpotentials and kinetics in the excited State.
3. Explain the concept of chemical kinetics, differentiate between homogeneous and heterogeneous catalysis
4. Explore the advanced solution thermodynamics and familiarize with the modern experimental techniques.

Mapping of Course Outcomes with POs and PSOs

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
M18CH235	CO1	2	1	2	2	1	2	0	0	0	1	2	2	2
	CO2	2	2	2	2	1	2	0	0	0	1	2	1	2
	CO3	2	3	2	1	2	1	0	0	0	1	2	2	3
	CO4	2	2	2	2	2	2	0	0	0	1	2	1	2

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. **[15 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. **[15 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 (H2 and O2 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

[15 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.

[15 hrs]

Reference Books:

1. Textbook of Physical Chemistry by Samuel Glasstone, MacMillan Indian Ltd., 2nd edition, (1974).
2. Elements of Physical Chemistry, S. Glasstone, MacMillan.
3. Solid State Chemistry – N.B. Hannay.
4. A Textbook of Physical Chemistry – G.M. Barrow. Mc Graw Hill – Tokyo, (1973).
5. Elements of Physical Chemistry – Lewis and Glasstone.
6. Theoretical Chemistry by S. Glasstone.
7. Statistical Themodynamics by B.C. Meclelland, Chapman and Hall, London (1973).
8. Elementary Statistical Thermodynamics by N.D. Smith Plenum Press, NY (1982).

9. Elements of Classical and Statistical Thermodynamics by L.K. Nash, Addison- Wesley (1970).
10. Statistical Thermodynamics by I.M. Klotz.
11. Introduction to Statistical Thermodynamics by M. Dole, Prantice-Hall, (1962).
12. Chemical Kinetics and Dynamics; Jeffrey I Steinfeld, Joseph S. Francisco and William L. Hase. Prentice Hall, 2nd edition, 1998.
13. Laidler, K. J.; "Chemical Kinetics", 3rd Edition 1997, Benjamin-Cummings. Indian reprint - Pearson 2009.
14. Laser Spectroscopy- Basic concepts and instrumentation – W. Demtroder (Springer 3rd edition, 2004).
15. K. K. Rohatgi - Mukkerjee, "Fundamentals of Photochemistry", Wiley Eastern Ltd., 1992.
16. W.J.Albery; Electrode kinetics Clarendon Press, Oxford 1975.
17. C.H. Banford and R.G. Compton (ed) Comprehensive chemical kinetics, Vol 26 Electrode kinetics – principles and methodology, Elsevier science publishers 1986

SEMESTER III -SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH313	16 Weeks	Photo physical processes and Applications (SC-3)	3	1	0	4

Course Objectives::

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

1. Principles and laws of photochemistry,
2. Measurement of fluorescence and phosphorescence and lifetimes
3. Fluorescence based sensors.

Course Outcomes:

After completion of course student will be able to,

1. Acquire knowledge on laws of photo chemistry, types of electronic transitions and their kinetics.
2. Study of various methods to understand fluorescence and phosphorescence processes.
3. Explain Fluorescence based sensors with relevant examples.

4. Describe principle of photovoltaics, various energy conversion devices and their applications.

Course Outcomes	Program outcomes									
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10
CO-1	2	2	0	0	1	2	2	0	1	2
CO-2	1	2	2	2	2	2	2	2	1	2
CO-3	2	1	2	3	2	1	3	2	2	2
CO-4	2	2	3	2	2	2	2	2	1	3

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.

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.

[20 hrs]

UNIT – II

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. **[20 hrs]**

UNIT – III

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. **[20 hrs]**

Reference Books:

1. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990)
2. Elements of Physical Chemistry, S. Glasstone, MacMillan.
3.Modern Spectroscopy, J M Hollas, John Wiley & Sons, 4th Edn, 2004
4. Modern Optical Spectroscopy, William W Parson, Springer, Student Edn, 2009
5.Fundamentals of Photochemistry, K K Rohatgi-Mukhejee, Wiley Eastern Ltd, 1992 6.Principles of Fluorescence Spectroscopy, J R Lakowicz, Springer, 3rd Edn, 2006 7.Laser Spectroscopy- Basic concepts and instrumentation – W. Demtroder (Springer 3rd edition, 2004)
8.Fundamentals of Photoinduced Electron Transfer, G. J. Kavarnos, VCH publishers Inc., New York, 1993.
9.Molecular Fluorescence: Principles and Applications, B. Valeur, Wiley-VCH Verlag GmbH, Weinheim, 2002.
10.Modern Molecular Photochemistry of Organic Molecules, N. J. Turro, V. Ramamurthy, J. C. Scaiano, University Science, Books, CA, 2010.
11.Photochemical Synthesis, I. Ninomiya, T. Naito, Academic Press, New York, 1989.

SEMESTER III -SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH323	16 Weeks	Energy and Energy conversion systems	3	1	0	4

Course Objectives: This course intended to provide student to

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

Course outcomes: Upon successful completion of this course, the student will be able to:

1. Asses the Renewable and non-renewable energies, their advantages and disadvantages, Environmental effects, Fossil fuels, Nuclear Energy.
2. Analyse the status of the renewable and non-renewable sources in the world and discuss the importance of renewable sources
3. Acquire the knowledge of renewable sources and list out the different renewable sources to convert, store, and usage in daily life.
4. Evaluate the efficiencies of solar cells, electrochemical energy conversion (HER and OER), storage (batteries, and supercapacitors) and fuel cells with their examples.

Energy and energy conversion system-III (MS17CH323)

Course Outcomes	Program Outcomes (MS17CH323)												
	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
CO-1	2	1	2	0	1	2	0	1	0	1	0	0	0
CO-2	1	0	1	0	1	2	1	1	0	0	1	1	1
CO-3	3	1	2	0	2	1	1	1	0	1	1	1	1
CO-4	2	2	2	2	2	2	1	1	0	1	2	3	2

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. **[15 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. **[15 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. **[15 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. **[15 hrs]**

Reference Books:

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

SEMESTER III -SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH333	16 Weeks	Advanced Physical Chemistry	3	1	0	4

Course objectives:

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

Course outcomes: After completion of the course student will,

1. Analyze the quantum mechanical aspects in the molecular dynamics.
2. Acquire knowledge on Schrodinger equation, particle in box, Characteristics of many electron systems.
3. Understand the statistical thermodynamics, non equilibrium thermodynamics, Molecular forces, Electrical properties of molecules.
4. Construct ideas pertaining to the statistical thermodynamics and macro molecular interactions.

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
MS17CH333	CO1	3	2	1	3	2	3	0	0	1	1	3	2	2
	CO2	3	2	1	1	2	2	0	0	1	1	3	2	2
	CO3	3	2	0	2	2	1	0	0	1	1	3	2	2
	CO4	3	2	3	1	1	1	0	0	0	1	3	2	2

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]**

Reference Books:

1. Quantum Chemistry – A.K. Chandra. 2nd edition, 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).
5. Quantum Chemistry – R.K. Prasad, New Age International Publishers, (1996).
6. Statistical Thermodynamics by I.M. Klotz.
7. Introduction to Statistical Thermodynamics by M. Dole, Prantice Hall, (1962).
8. Statistical Themodynamics by B.C. Meclelland, Chapman and Hall, London (1973).
9. Physical Chemistry by P.W. Atkins, ELBS, 4th edition, Oxford University Press (1990)
10. Elements of Physical Chemistry, S. Glasstone, MacMillan.11. Thermodynamic Properties of Nonelectrolyte Solutions, Acree W.E., (Academic Press, 1984)
12.Chemical Thermodynamics: Advanced Applications, J. Bevan Ott, Juliana Boerio-Goates, (Academic Press, 1st edition, 2000).
13.The Molecular Theory of Solutions, Prigogine, (North Holland Publishing Co. Amsterdam 1957).
14.Molecular Theory of Solutions, Arieh Ben-Naim, (Oxford University Press, USA, 2006)

SEMESTER III -SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH343	16 Weeks	Polymer Science and Technology	3	1	0	4

Course objectives:

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

Course outcomes: *After completion, of course student will*

CO-1: Demonstrate the knowledge of the basic concept of polymer, analysis of molecular weight of polymer.

C0-2: Explore physical factors of polymers, analysis of glass transition temperature of polymer, Thermodynamic equation of polymer.

C0-3: Create broad knowledge on polymer classification, mechanism of polymerization, instrumentation method of polymer characterization.

C0-4: Acquire broad knowledge of polymers for medical, environmental, catalysis and device applications

Course outcome (COs)	Program outcomes (POs)										Program Scientific outcome (PSO)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PS02	PSO3
CO1	2	1	0	2	1	0	0	0	0	0	2	2	1
CO2	2	0	0	2	1	0	0	0	0	0	2	2	1
CO3	2	1	0	1	1	0	0	0	0	0	2	2	1
CO4	2	0	2	0	0	1	0	0	0	0	2	2	1

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 polymerisation, Moulding and fabrication of polymer.Introduction to Instumental methods for characterisation 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. **[15 hrs]**

Reference Books:

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.

9. Text book of Polymer Science by Billmeyer, John Wiley ans Sons 1984.

10. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.

11. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.

12. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.

13. Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977

SEMESTER III -SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH353	16 Weeks	Fundamentals of Electrochemistry and applications	3	1	0	4

Course of Objective (CO): To make the student conversant with

i. Explain the fundamental concept, principles and laws of electrochemistry,
ii. Types of electrodes and study of electrode reactions pathway.
iii. The concept of spectro-electrochemical and spectroscopic techniques.
iv. The Construction of electrode materials for various application.

Course of Outcome (CO): By the completion of course student will be able to

1. Apply the knowledge about the electrochemical reaction and mechanism.
2. Explain the devlopment of electrode materials in various applications.
3. Apply the spectro-electrochemical and spectroscopic in better understanding structural feature and prospective of electrode materials.
4. Design the new electrode materials for various application in the field of electrochemical sensors and electrochemical energy devices.

Mapping of Course Outcomes with programme Outcomes (sample)

Course	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3

Code														
	CO 1	2	2	3	3	3	3	0	0	1	2	3	3	3
	CO 2	2	3	1	3	2	2	0	0	1	2	3	4	3
	CO 3	3	3	1	4	3	0	0	0	1	2	3	5	3
	CO 4	2	2	3	3	3	3	0	0	1	2	3	3	3

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 tunnelling

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. **[20 hrs]**

UNIT – II

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, coulmetry, pulse techniques

Spectro-Electrochemical and Spectroscopic Techniques: Impedance Spectroscopy, Scanning Electrochemical Microscopy, Electrochemical AFM and STM, Electrochemical Quartz Crystal Microbalance, Photoelectochemistry. **[20 hrs]**

UNIT – III

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

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. **[20 hrs]**

Reference Books:

1. Electrochemical Methods: Fundamentals and Applications, Allen J. Bard and Larry R. Faulkner, 2nd edition 2001, John Wiley & Sons

2..Electroanalytical Chemistry, Allen J. Bard (Ed, Vol.13, Plenum Press 1983

3. Analytical Electrochemistry, Joseph Wang, 3rd edition 2006, John Wiley & Sons

4. Electrochemistry of Functional Supramolecular Systems, Paola Ceroni, Alberto Credi and Margherita Venturi (Ed), 2010, John Wiley & Sons

5. Electrochemistry in Non-aqueous Solutions, Kosuke Isutzu, Wiley – VCH Verlag GmbH & Co. 2002

6. Dye-Sensitized Solar Cells, K. Kalyanasundaram (Ed), EPFL Press, 1st Edition 2010(ISBN 978-2-940222-36-0)

7. Electrochemical Systems, J. Newman, Wiley-Interscience, 3rd edition 2004

Analytical Chemistry

SEMESTER I -HARDCORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH104	16 Weeks	Analytical Chemistry I	3	1	0	4

Course Objectives: This course aims to provide students the following concepts;

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

Course Out comes: After the completion of this course, students 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 Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO1	1	1	2	2	2	0	0	1	0	0	0	0	1
	CO2	2	1	2	2	2	0	0	1	0	0	1	1	1
	CO3	2	1	1	1	2	0	0	2	0	0	2	1	2
	CO4	2	2	2	2	3	0	0	2	0	0	2	3	2

UNIT – I

Analytical Chemistry - Meaning and analytical prospective, scope and function: Analytical problems and their solutions, trends in analytical methods and procedures.

Language of analytical chemistry - Analysis, determination and measurement. Techniques, methods, procedures and protocols. Classifying analytical techniques. selecting an analytical method - accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Scale of operation, equipment, time and cost. Making the final choice

Errors and treatment of analytical data: Limitations of analytical methods – Error: determinate and indeterminate errors, minimization of errors. Accuracy and precision, distribution of random errors, the normal error curve. Statistical treatment of finite samples - measures of central tendency and variability: mean, median, range, standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance - comparison of two means and two standard deviations. Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation - Q-test. Propagation of errors: determinate errors and indeterminate errors.

[15 Hrs]

UNIT – II

Titrimetric analysis: An overview of titrimetry. Principles of titrimetric analysis. Titration curves. Titrations based on acid-base reactions - titration curves for strong acid and strong base, weak acid

and strong base and weak base and strong acid titrations. Selecting and evaluating the end point. Finding the end point by visual indicators, monitoring pH and temperature.

Acid-base titrations in non-aqueous media: Role of solvent in acid-base titrations, solvent systems, differentiating ability of a solvent, some selected solvents, titrants and standards, titration curves, effect of water, determining the equivalence point, typical applications - determination of carboxylic acids, phenols and amines.

Precipitation titrations: 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. **[15 Hrs]**

UNIT-III

Complexometric titrations: Complex formation reactions, stability of complexes, stepwise formation constants, chelating agents, EDTA - acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves, effect of other complexing agents, 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, titration of mixtures.

Introduction to Electro-analytical techniques:

Electrode Potentials, Currents in Electrochemical cells, Introduction to Electrode processes, Potentiometric titrations. Electrogravimetry, Coulometry, and Coulometric titrations. Amperometry Voltammetry 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 – tests for the reversibility of a process – irreversible processes at a DME – factors that set the sensitivity and selectivity limits in normal dc polarography. **[15 Hrs]**

UNIT-IV

SOLVENT EXTRACTION

Partition coefficient-equation for batch extraction & multiple extraction, Extraction efficiency- pH effects, Extraction with metal chelator and crown ethers. Ion-exchange separation

CHROMATOGRAPHY

Types of chromatography –Theoretical principles; Retention time, retention volume, adjusted retention time, relative retention, capacity factor (retention factor) –Relation between retention time and partition coefficient –Scaling up, scaling rules-Efficiency of separation, resolution -Ideal chromatographic peaks (Gaussian peak shape)- Factors for Resolution-diffusion, diffusion coefficient - Plate Height- Plate Height as a Measure of Column Efficiency-Number of theoretical plates-asymmetric peaks- Factors Affecting Resolution -Band Spreading- van Deemter equation, Optimum Flow Rate, A Term – multiple paths, longitudinal diffusion, Mass Transport, Extra column contributions to zone broadening -advantages of open tubular columns- isotherms and the resulting band shapes.

Thermal Methods

Thermo garavimetry –Principle, Factors affecting the results, instrumentation. Application with special referenceto CuSO4.5H2O, CaC2O4 .2H2O. Different thermal analysis principle, instrum entation,Difference between TG and DTA,Applications with special reference to the clays and mi nerals.Different scanning calorimetry principle, and applications to inorganic materials like chlor ates and perchlorates, ammonium nitrate. [15 Hrs]

Reference Books:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, 2005, Saunders College Publishing, New York.

2. Analytical Chemistry, G.D. Christian, 5th edition, 2001, John Wiley & Sons, Inc, India.

3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, Prentice Hall, Inc. New Delhi.

4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.

5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.

6. Principles and Practice of Analytical Chemistry, F.W. Fifield and Kealey, 3rd edition, 2000, Blackwell Sci., Ltd. Malden, USA.

7. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, 2000.

SEMESTER I –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH145	**16 Weeks**	**ADVANCED INSTRUMENTAL METHODS OF ANALYSIS**	**3**	**1**	**0**	**4**

Course Objectives:

This course aims to provide students

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

Course Out comes:

After completion of the course the student shall be able to:

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

Course Code	POS/ COs	PO1	PO 2	PO3	PO4	PO5	PO6	P7	PO8	PO9	PO 10	PSO 1	PSO 2	PSO 3
	CO1	2	1	1	2	3	1	0	0	1	2	2	2	3
	CO2	1	2	1	3	3	1	0	0	1	2	1	1	3
	CO3	2	2	2	1	2	1	0	0	2	2	1	3	2

	CO4	2	3	2	3	3	2	0	0	2	2	2	2	1

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. **[15 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, applications. Mass spectrometry in the analysis of inorganic compounds-different techniques, applications. **[15 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-priciple and applications, Polarography, Pulse polarography, Amperometry-titrations, different titration curves, applications, numerical problems on all these techniques**.** **[15Hrs]**

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. Biomolecules-Analysis: Introduction, single biomolecule detection and characterization, Fluorescence, principle, factors influencing fluorescence, fluorescence based biosensors, Fluor immunosensors, Mass spectrometry-principle, sample preparation, probe tip, MALDIMASS, types of ion separation, instrumentation-types, applications in structural biology, Application of NMR spectroscopy in the analysis of biomolecules, Raman spectroscopy- phenomenon, merits and limitations, application to biomolecules. **[15 Hrs]**

Reference Books:

1. Analytical Chemistry. Gary D Christian, 5th Edition, John – Wiley and Sons Inc., (1994)
2. Fundamentals of Analytical Chemistry.D. A. Skoog, D. M. West and F. J. Holler, 7th Edition, 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: A.J. Bard & l. R. Faulkner, 2nd edition, Wiley, New York, 2000.
6. Vogel's text book of Quantitative Chemical analysis 5th edition, Ed., Jeffery et. al ELBS/Longman, 1989
7. Encyclopedia of Analytical Chemistry: Ed. By R.A. Meyers Vol. 1 – 15, John Wiley, 2000.
8. Fundamentals of Instrumental Analysis, Skoog, D. M. West and F. J. Holler, 8th Edition, Saunders College Publishing (2004).

SEMESTER II -HARDCORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH204	16 Weeks	ORGANIC SPECTROSCOPY	3	1	0	4

1. **Course objectives**: This course is intended to provide the student to
2. a. Device the basic concepts of UV-Visible and IR spectroscopic techniques to analyze the chemical compound and structure,
3. b. Analyze the organic compound structure by using the knowledge of Chemical shift values and data interpretation.
4. c. Evaluate the mass of the organic compound by the fragmentation pattern and study the compounds by different modern ionization techniques.

5. d. 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: On successful completion of the course students shall 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 Outcomes	Program Outcomes												
	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**
CO-1	1	2	0	0	3	1	3	1	2	2	2	3	3
3CO-2	1	2	0	1	3	2	3	1	2	2	2	3	3
CO-3	1	2	0	1	3	2	3	1	2	2	2	3	3
CO-4	1	1	0	0	2	1	2	1	2	1	2	1	2

6.

UNIT-I

UV AND VISIBLE SPECTROSCOPY

Terminology, classification of electronic transitions. Effect of substituent and conjugation on the spectra of alkenes. Woodward – Fisher rules for polyenes. Electronic spectra of carbonyl compounds. Effect of solvent on $\pi - \pi^*$ and $n - \pi^*$ transitions. Woodward's rules for eons. Electronic spectra of benzene and its derivatives.

INFRARED SPECTROSCOPY

Technique and instrumentation, 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, acids, anhydrides). Effect

of solvent and hydrogen bonding on the vibrational frequencies in alcohols. IR spectra of metal complexes involving ammine, aquo, hydroxo and carbonyl ligands. **[15 Hrs]**

UNIT-II

NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Introduction. Nuclear spin and nuclear parameters. NMR nuclei. Nuclear spin states. The mechanism of absorption (resonance condition). Calculation of resonance frequency. Population densities of nuclear spin states. Relaxation processes.

The chemical shift and shielding. Chemical environment and chemical shift. Factors affecting chemical shift. Magnetic anisotropy. Continuous wave and pulsed Fourier methods of recording NMR spectra. 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 spetrum. First and second order coupling of AB systems. Spin decoupling methods. Double resonance. Applications in structural elucidation.

[15 Hrs]

UNIT-III

CARBON–13 NMR SPECTROSCOPY

The carbon – 13 nucleus, carbon – 13 chemical shift. Proton coupled and proton decoupled carbon – 13 spectra. Nuclear overhauser effect. Problems with integration in carbon -13 spectra. Off resonance decoupling. Applications.

MASS SPECTROMETRY

Introduction, principle and instrumentation. Ion production – electron impact, chemical ionization, field desorption and fast atom bombardment techniques. High resolution mass spectrometry – base -, 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, acids and esters). McLafferty rearrangement. Determination of molecular weight and molecular formula.

[15 Hrs]

UNIT-IV

ELECTRON SPIN RESONANCE SPECTROSCOPY

Theoretical principles, 'g' factor, hyperfine splitting, Illustration of hyperfine splitting using examples, cyclopentadienyl radical, radical anions of benzene, naphthalene, p-benzo semiquinone. 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 substitutional impurity in MgO.

MOSSBAUER SPECTROSCOPY

Mossbauer effect and Mossbauer nuclei, isomer shift, quadrupole splitting and magnetic hyperfine interactions, elucidation of electronic structures of Fe(II) and Fe(III) systems.

[15Hr]

Reference Books

1. Physical methods in Inorganic chemistry, R.S. Drago, Affiliated East-West Press Pvt. Ltd., New Delhi (1965).
2. Infrared Spectra of Inorganic and coordination Compounds, K. Nakamoto, Wiley-Interscience, New York, (1970).
3. Vibrational spectroscopy: theory and Applications, D.N.Sathyanarayana, New-Age International Publishers, New Delhi (2000).
4. Electronic Absorption Spectroscopy and related techniques, D.N.Sathyanarayana, Universities Press, Bangalore, (2001).
5. Applications of absorption Spectroscopy to Organic Compounds, J.R. Dyer, Prentice – Hall, New Delhi, (1969).
6. Organic Spectroscopy, W. Kemp, ELBS London, (1975).
7. Spectrometric Identification of Organic Compounds, R.M. Silverstein and W.P. Webster, Wiley & Sons, (1999).
8. Organic Mass Spectroscopy, K.R. Dass and E.P. James, IBH New Delhi, (1976).
9. Mass Spectrometry of Organic Compounds, H. Budzkiewicz, Djerassi C. and D.H Williams, Holden-Day, New York, (1975).
10. Principles of Instrumental Analysis, D.A. Skoog, S.J. Holler, T.A. Nilman, 5th Edition, Saunders College Publishing, London, (1998).
11. Introduction To Spectroscopy, 2nd Edition, Donald L. Pavia, Gary M. Lampman and George S. Keiz, Harcourt Brace College Publishers, (1996).
12. Physical Methods for Chemists, R.S. Drago, 2nd Edition, Saunders College Publishing New York, (1992).
13. Mass Spectrometry Analytical Chemistry By Open Learning R. Davies, M. Frearson and E. Prichard, John Wiley and Sons, New York, (1987).
14. Modern NMR techniques For Chemistry Research, Vol. 6, A.E. Derome, Oxford Pergamon Press, (1987).

15. Spectroscopic Methods in Organic Chemistry, 4th Edition, D.H. Williams and I. FlemingTata-McGraw Hill Publications, New Delhi, (1988).

SEMESTER II –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH245	16 Weeks	SEPARATION AND ELECTRO ANALYTICAL TECHNIQUES	3	1	0	4

Course Objectives: This course aims to provide students to knowledge on

Detailed theoretical background of various separation and electroanalytical techniques.

Various types of liquid chromatographic techniques.

Detailed working of both GC and HPLC techniques.

Principle and applications, of electro analytical techniques like electrophoresis and Voltammetry.

Course Out comes: After the completion of this course, students 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: Analyze principles that govern compounds separation

CO4: Outline the role of electroanalytical techniques for materials analysis

POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO1	2	2	0	2	1	1	0	0	0	0	1	2	2
CO2	2	1	0	2	1	1	0	0	0	0	2	2	2
CO3	2	2	1	1	2	2	0	1	0	0	1	2	1
CO4	2	1	2	2	2	1	0	2	0	0	2	2	2

UNIT-I

LIQUID CHROMATOGRAPHIC METHODS

(i) Reversed phase chromatography for neutral samples. Reverse phase retention process-selectivity- Solvent type selectivity and column selectivity-isomer separations.

(ii) Normal phase Chromatography- Retention mechanism -solvent strength-use of TLC data for predicting NPC retention- Solvent type selectivity and column selectivity-isomer separations.

(iii) Ion Exchange chromatography- ion exchangers, resins-ion exchange selectivity, selectivity coefficient, Donnan Equilibrium- Conducting ion exchange chromatography, Gradient elution, Application of ion exchange.

(iv) Ion Chromatography-Suppressed ion –anion and Cation chromatography-Ion chromatography without suppression-detectors-ion pair chromatography

(v) Molecular exclusion chromatography - The elution equation, stationary phase, molecular mass determination.

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

(vii) Hydrophilic interaction chromatography (HILIC).

Sample Preparation:

Statistics of sampling-choosing a sample size-choosing the number of replicates. dissolving samples for analysis., dissolving inorganic material, dissolving organic material, decomposition of organic substances, sample preparation techniques and derivatisation.

[15 Hrs]

UNIT-II

GAS CHROMATOGRAPHY

Separation process in gas chromatography –schematic diagram-

open tubular columns,Comparison with packed columns, Effect of column inner diameter a nd length of the

olumn, choice of liquid stationary phase, chiral phases for separating optical isomers-

molecular sieves as stationary pahase-packed columns-Retention index-Temperature and pressure programming -Carrier gas-Guard columns and retention gaps-sample injections, split injection and split less injection, solvent trapping and cold trapping, on column injection- Detectors : thermal conductivity detector, flame ionisation detector, electron capture detector, Mention about other detectors like nitrogen phosphorous detector, flame photometric detector, photoionisation detector, sulphur chemiluminescence detector -GC- MS-Element specific plasma detectors. Sample preparation-solid phase micro extraction, purge and trap, thermal desorption-*Derivatisation in GC*-Method development in GC.

[15 Hrs]

UNIT-III

HIGH-PERFORMANCE LIQUID CHROMATOGRPHY

The chromatographic process-effect of small particles, scaling relation between columns, relation between number of theoretical plates and particle size, column pressure-The column, stationary phase, monolithic silica columns-Bonded stationary phases-solute column interactions-shape selectivity-The elution process, isocratic and gradient elution, selecting the separation mode, solvents, Maintaining symmetric band shape, dead volume – Injection and detection in HPLC, Detector characteristics, signal to noise ratio, detection limits, Linearity- Spectro photometric detectors, refractive index detector, Evaporative Light scattering detector, Method development in reverse phase separation-Criteria for adequate separation-Optimisation with one solvent, optimization with two or three different solvents-choosing a stationary phase-Gradient separations- Dwell volume and Dwell time-developing a gradient separation. Chiral separation.- derivatives for HPLC. **[15 Hrs]**

UNIT-IV

Electrophoresis and Electrochromatography

General introduction to electrophoresis. Important terms- Basis of electrophoretic eparation. Expression for distance traveled on application of electrode potential. Role of buffer in electrophoresis.Classical gel electrophoresis, High performance capillary electropho resis advantages.Instrumentation set up; sample injection. Comparison of classical and capillary electrophoresis. Electroosmotic flow. Modes of electrophoresis.

Capillary gel electrophoresis, capillary isoelectric focusing; capillary isotachophoresis. Capillary electrochromatography (basic principle) Micellar electrokinetic capillary electophoresis.

Ion Selective Electrodes

Brief Introduction- Potentiometry- electrodes used: Metallic indicator electrodes: types with one example for each. Metallic redox indicator electrodes. Ion selective electrodes ISE: Classification of membranes. Properties of ISE.

Glass membrane electrodes. Composition and structure of glass membrane. Hygroscopicity of glass membrane. Electrical conductance across the glass membrane. Membrane and boundary potential Expression for Eb. Alkaline error. Crystalline membrane electrode. Conductivity of a crystalline membrane.

Voltammetric Techniques*:*

Introduction to voltammetric techniques. Polarization – Ideal polarized and ideal non polarized electrodes: Sources of polarization. Reaction and concentration polarization. Mechanism of mass transport. The current response to applied potential (in terms of Fermi and molecular orbitals) Faradaic and non- Faradaic currents. Charging and residual currents. **[15 Hrs]**

Reference Books:

1. Quantitative Chemical Analysis, Daniel C.Harris,7th edition., (W. H. Freeman and Company, New York, 2006).
2. Principles of Instrumental Methods of Analysis-

Skoog, Holler And Nieman, 5thedition,Saunders College Publishing, International Ltd. (1998).

3. Hand Book of Instrumental Techniques For Analytical Chemistry, Frank Settle, Prentice Hall PTR, (1997).
4. Unified Separation Science-J. Calvin Giddings –John Willy& Sons (1991).
5. Chromatography –Concepts And Contrasts -James M Miller- John Wiley& Sons (1988).
6. Analytical Chemistry: Principles –John H Kennedy, Second Edition, Saunders College Publishing (1990).
7. Experimental Organic Chemistry, Daniel R. Palleros, John Willy& Sons (1999).
8. Fundamentals of Analytical Toxicology, Robert J Flanagan et.al. John Willy& Sons (2007).
9. Fundementals of Analytical toxicology , Robert J Flanagan, Andrew Taylor et al John Wiley & Sons Ltd (2007).
10. Introduction to modern liquid chromatography –Lloyd R.Synder, Joseph J. Kirkland et al; third edn; John Wiley & Sons Ltd (2010)

11. Principles of Instrumental Analysis, Skoog, Holler and Nieman, 5th edition, Saunders college Publishing, International Limited (1999).
12. Analytical Chemistry Principles – John H Kennnedy, 2nd edition, Saunders College Publishing (1990).
13. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).
14. Vogel's Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited, (2007).
15. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).
16. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7th edition, CBS Publishers

Semester: II – Analytical Chemistry Practical

Course Code	Duration	Course Title	L	T	P	C
MS17CH207	**16 Weeks**	**Lab course in Analytical chemistry**	**3**	**1**	**0**	**4**

Course Objectives: The practical course on Analytical chemistry intends to provide the students

a. to acquire the scientific skills in qualitative and preparative techniques.
b. to appreciate the importance of being systematic in life.
c. to understanding of chemical methods employed for elemental and compound analysis.
d. to 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. Develop the critical thinking, punctuality, team work and honesty during the conduction of the experiments

Lab course in Analytical Chemistry-II (M17CH207)

Course Outcomes	Program Outcomes												
	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**
CO-1	1	2	1	1	3	2	2	1	2	2	2	1	1
CO-2	1	2	1	1	3	2	2	1	2	2	2	1	1
CO-3	1	2	0	1	3	2	2	1	2	2	2	1	1
CO-4	1	2	0	0	2	2	2	2	2	1	1	0	0

PART – I

1. Determination of purity of a commercial boric acid sample, and Na_2CO_3 content of washing soda.
2. Analysis of chromate-dichromate mixture by acid-base titration.
3. Determination of replaceable hydrogen and relative molecular mass of a weak organic acid by titration with NaOH.
4. Analysis of water/waste water for alkalinity by visual, *p*H metric and conductometric titrations.
5. Flame emission spectrometric determination of sodium and potassium in river/lake water.
6. Determination of calcium in limestone by redox, acid-base and complexation titrations.
7. Determination of aluminium and magnesium in antacids by EDTA titration.
8. Determination of saccharin in tablets by precipitation titration.
9. Determination of iodine value and saponification value of edible oils.
10. Analysis of a mixture of iron(II) and iron(III) by EDTA titration using *p*H control.
11. Potentiometric titration of a mixture of chloride and iodide.

PART – II

1. Analysis of waste waters for DO and COD by titrimetry.
2. Photometric and potentiometric titration of iron(III) with EDTA.
3. Photometric and potentiometric titration of copper with EDTA.
4. Conductometric titration of sodium acetate with HCl and NH4Cl with NaOH.

5. Spectrophotometric determination of iron in natural waters using thiocyanate and 1,10-phenanthroline as reagents.

6. Analysis of a soil sample

7. Determination of total hardness, calcium and magnesium hardness and carbonate and bicarbonate hardness of water by complexation titration using EDTA.

8.Analysis of commercial hypochlorite and peroxide solution by iodometric titration.

9.Determination of ascorbic acid in vitamin C tablets by titrations with $KBrO_3$ and of vitamin C in citrus fruit juice by iodimetric titration.

10. Cation exchange chromatographic separation of cadmium and zinc and their estimation by EDTA titration.

11. Thin layer chromatographic separation of amino acids.

Reference Books:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.

2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India.

3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993, prentice Hall, Inc. New Delhi.

4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003 Pearson Education Pvt. Ltd., New Delhi.

5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.

6. Pharmaceutical Drug Analysis by Ashutoshkar, New Age International Publishers, New Delhi, 2005.

7. Practical Pharmaceutical Chemistry, Ed. A. H. Geckett, J. B. Stenlake, 4th edition. Part I and II, CBS Publishers, New Delhi.

8. Quantitative Analysis of Drugs in Pharmaceutical Formulations, P. D. Sethi, 3rd edition, CBS Publishers & Distributors, New Delhi, 1997.

9. Practical Clinical biochemistry methods and interpretations, R. Chawla, J.P. Bothers Medical Publishers (P) Ltd., 1995.

10. Laboratory Manual in Biochemistry, J. Jayaraman, New Age International Publishers, New Delhi, 1981.

11. Practical Clinical Biochemistry, Harold Varley and Arnold. Heinmann, 4th edition.

12. Environmental Science: Laboratory Manual, Maurice A. Strabbe, The C.V. Mosbey Co. Saint Loucs, 1972.

13. Experiments on Water Pollution, D.I. Williams and D. Anglesia, Wayland Publishers Ltd., England, 1978.

14. Experiments on Land Pollution, D.I. Williams and D. Anglesia, Wayland Publishers Ltd., England, 1978.

15. Experiments in Environmental Chemistry, P.D. Vowler and D.W. Counel,PergamonPress, Oxford 1980.

16. Manual Soil Laboratory Testing, vol. I, K.H. Head, Pentech Press, London

SEMESTER III –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH314	16 Weeks	ENVIRONMENTAL CHEMISTRY AND APPLIED ANALYSIS	3	1	0	4

Course Objectives: Students should be able to

1. Demonstrate a knowledge and understanding of the basic facts and experimental basis of environmental chemistry.

2. Develop an understanding of how chemists approach and attempt to solve environmental problems.

3. Review the basic principles of analytical procedures to analyze food constituents and Evaluate quality control results and estimation of vitamins, lipids and other minerals.

4. Describe the mechanism of drug molecules, principles and procedures of various tests performed in Clinical Chemistry laboratory.

Course outcomes: Students will be able to learn

CO1: To create environmental awareness to understand the vulnerability and sensitivity of environment. To promote a sense of responsibility and proactive citizenship.

CO2: Execute chemical analysis of various pollutants in the environment and 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.

PROGRAMME OUTCOMES													
Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**1**	**0**	**1**	**3**	**3**	**1**	**1**	**3**	**0**	**1**	**0**
CO2	**1**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**1**	**1**
CO3	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**0**	**0**	**1**	**1**	**3**	**1**
CO4	**1**	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**0**	**1**	**2**	**3**	**2**

UNIT – I

Environmental Chemistry: Introduction: Environmental chemistry, environmental segmentsclassification of environmental pollution.

Air Pollution: Introduction, Air pollutants, Primary pollutants, Sources (CO, NOx, HC, SO2, and particulates).Particulates Sources (Inorganic and organic particulate matters).Effects on: Humans, materials, vegetation and animals.

Air quality standards, Sampling, monitoring and analysis: CO by gas chromatography, NOx by Spectrophotometric method using sulphanilamide and NEDA, SO2 by pararosaniline (PRA), H2Sby colorimetric using ethylene blue, hydrocarbons by chemiluminescence,control of airpollution: 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.

[15 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: Moisturemeasurement by gr avimetric method, pH using calomel glass electrode method, total nitrogen bykjeldhal method, d etermination of nitratenitrogen by Bratton and Marshal method,determination of potassium and s odium by Flame photometry, calcium by EDTA titration ,organic matter by combustion, total sul phur by oxidation as sulphate.

[15 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.

[15 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, protein precipitants. Interpretation and 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. **[15 Hrs]**

Reference Books:

1. Dr. H. Kaur, Environmental Chemistry (2010)
2. Khopkar. S. M, Environmental pollution, monitoring and control, IIT Mumbai (2004)
3. Asim K. Das, Environmental Chemistry with Green Chemistry (2010)
4. P. R. Hesse , A text book of Soil Chemical Analysis (2002)
5. A. K. De, Environmental Chemistry (7th edition), Uttarpara West Bengal (2010)
6. N. Manivasakam, Physico chemical examination of water, sewage and industrial effluents (6th edition 2010)
7.Hand book of Analysis and Quality control for fruit and vegetable products. S Ranganna, Tata McGraw-Hill Publishing Co. Ltd, Second Edition
8. Pharmaceutical Drug Analysis. AshutoshKar, New Age International Publishers
9. Practical Clinical Biochemistry, Harold Varley, Fourth Edition
10. Food Analysis, A G Woodman, McGraw-Hill
11. Principles of Medicinal ChemistryVol 1, Dr. S S, Kadam, Dr. K R Mahadic, Dr. K G Bothara, Niraliprakashan.

SEMESTER III –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH324	16 Weeks	ADVANCED SURFACE ANALYSIS AND ELECTRON SPECTROSCOPY	3	1	0	4

Course Objectives:

1.Explain emerging trends in nanotechnology and scope of other materials like zeolites

2.Discuss the various techniques involved in synthesis of ceramics and nanomaterials

3.Make use of different spectroscopic techniques for chemical analysis

4. Analyze the applications of nanomaterials in various fields like agriculture, health, electronics , medical , food safety etc .

Course outcomes:

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- List the application of nanomaterials in various fields like agriculture, health, electronics , medical , food safety etc.

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. **[15Hrs]**

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. **[15 Hrs]**

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)

Applications:

Nanotechnology in modern technology in relation to electronic, biological, consumer and domestic applications. Energy related application: photo-volatile cells. Energy storage nanomaterials. Sensors: Agriculture, health and medical, food, security. Applied nanobiotechnology and nanobiomedical science drug delivery, drug targeting, biosensors, bioimaging, neutron capture therapy. **[15Hrs]**

Reference Books:

1. Encylopedia of nanomaterials and nanotechnologies, H. S. Nalva.

2.Nanostructures materials: Processing, Properties and applications, C. C. Kouch, William Andrew publications, Newyork, 2002.

3.Introduction to nanotechnology, C. P. Poole Jr, F. J. Owens, 2nd edition, Wiley-India, Delhi, 2008.

4. Nanostructures and nanomaterials, G. Cao, Imperial College Press, University of Washington, USA, 2004.

5

. Biomaterials, S. V. Bhat, 2nd edition, Narasa Publishing house, New Delhi, 2005.

6.Nanotechnology Fundamentals and applications, M. Karkare, I. K. international publishing house pvt. Ltd., Bangalore, 2008.

7. Nanomaterials: Synthesis, properties and applications, A. S. Edelstein, T. C. Cammarata, Inst. Of. Physics, UK, 1966.

8. Springer Handbook of Nanotechnology, B. Bhusan, 3rd edition, Springer-Verlag, 2009.

9. Chemistry of Nanomaterials: Synthesis, Properties and Applications, CNR Rao and T. Cheetham, Wiley & Sons, 2005.

10. Encyclopedia of Nanotechnology, Hari Singh Nalwa, American Scientific Publishers, 2004.

MAPPING OF CO-PO

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	2	3	1	0	0	0	0	2	3	3
CO 2	3	3	0	2	3	0	0	0	0	0	2	3	3
CO 3	3	3	0	0	3	0	0	0	0	0	2	3	3
CO 4	1	0	1	1	3	2	0	0	0	1	3	0	2

SEMESTER III –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH334	**16 Weeks**	**WATER CHEMISTRY AND TREATMENT TECHNOLOGY**	**3**	**1**	**0**	**4**

Course Objectives: This course aims to provide the student to:

1. Determine the basic concepts of water pollution, various water analysis methods like COD, BOD, TOC, hardness and properties of water.
2. Analyze the estimation of dissolved oxygen, alkalinity, acidity and chlorides in water, Water treatment for domestic purpose.
3. Define the Ion-Exchange and Permutit processes, Lime soda process.
4. Conclude the Biological relevance of pH and pKa of functional groups in biopolymers, proteins and nucleic acids.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Differentiate between the Organic pollutants and Inorganic pollutants
2. Acquired the knowledge about Acid-base reactions and alkalinity/acidity to solve problems associated with water/wastewater treatment and natural water quality.
3. Explain the hardness of water and their internal and external treatment
4. Analyze Properties of water and Buffers, pH value of various bio-entities

Course outcomes	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
CO-1	1	2	1	0	0	1	1	1	0	0	1	0	0

CO-2	1	2	1	2	0	2	1	0	1	1	1	0	1
CO-3	2	2	1	1	0	2	1	1	0	0	1	0	1
CO-4	3	1	1	0	1	2	1	1	0	0	1	0	1

UNIT-I

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. [15Hrs]

UNIT-II

Determination of Hardness of water and its Units, Disadvantages of hard water, Estimation of hardness by EDTA method, Numerical problems on hardness, Estimation of dissolved oxygen, Alkalinity, acidity and chlorides in water, Water treatment for domestic purpose (Chlorination, Bleaching powder, ionization)

Industrial Use of water:

For steam generation, troubles of Boilers: Scale & Sludge, Priming and Foaming, Caustic Embrittlement and Boiler Corrosion. **[15Hrs]**

UNIT-III

Treatment of Boiler Feed water:

Internal Treatment: Colloidal, Phosphate, Carbonate, Calgon and sodium aluminate treatment.

External Treatment: Ion-Exchange and Permutit processes, Lime soda process.

Demineralization of brackish water: Reverse Osmosis and Electro dialysis Determination of turbidity of wastewater,Total solids , volatile solids and fixed solids of wastewate r, nitrogen, Phosporous from waste water. **[15Hrs]**

UNIT-IV

PROPERTIES OF WATER

Ionic product of water and its measurements. Importance of water in biological system with special reference to the maintenance of the native structure of biological molecules. Types of bonding in biological molecules. Biological relevance of pH and pKa of functional groups in biopolymers, proteins and nucleic acids. Buffers, pH value of various bio-entities, buffer action, buffer capacity and their importance in biological systems. Isoelectric points for amino acids. Titration of proteins and preparation of buffer.

Karl-Fischer titrations:

Stoichiometry of the reaction, preparation of the reagent, titration method, standardization of the reagent using water-in-methanol, determination of water in samples, interference and their elimination, application to quantitative analysis of some organic compounds- alcohols, carboxylic acids, acid anhydrides and carbonyl compounds. **[15Hrs]**

Reference Books:

1. A Text Book of Enigneering Chemistry, Jain and Jain, Dhanapathi Rai Publications, New Delhi
2. Engineering Chemistry by K.B.Chandra Sekhar, UN.Das and Sujatha Mishra, SCITECH, Pubblications India Pvt Limited.
3. Concepts of Engineering Chemistry- Ashima Srivastavaf and N.N. Janhavi
4. Text Book of Engineering Chemistry – C. Parameswara Murthy, C.V.Agarwal and Andra Naidu
5. Chemistry of Engineering Materials, C.V.Agarwal, C.Parameswaramurthy and Andranaidu
6. Text Book of Engineering Chemistry, Shashichawla, Dhanapathirai Publications.

SEMESTER III –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH344	16 Weeks	FUNDAMENTALS OF ELECTROANALYTICAL TECHNIQUES	3	1	0	4

Course Objectives: This course intended to provide student to

a. Conclude the different types of conductivities dealt in electrode system which are involved in the determination of properties of electrolytes.

b. Defend the following topics: pulse polarography, coulometry, polarography Types of electrodes and systems, redox systems, membrane electrodes, double layer, theories related to electrochemistry, electrochemical interfaces.

c. Analysis the importance of electrochemistry, their economic importance, chemical principles and challenges in energy storage devices.

d. Develop practical skills to design the industrially important energy materials by the acquired the knowledge from principles of electrochemistry.

Course outcome

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

CO1. Illustrate the chemical reactions involved in the determination of conductivities related to different systems.

CO2. Conclude the reactions and solve problems relating to the energy production process in electrochemistry written and verbal.

CO3. Analyze the energy storage device designed by industry with suitable technique.

CO4. Understand the emissions of materials related to environmental issues pertaining to the manufacturing industry.

Course Outcomes	Program Outcomes

	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	
CO-1	2	1	0	1	1	1	0	1	0	1	1	1	2	
CO-2	1	2	1	1	2	2	1	1	0	1	2	2	1	
CO-3	1	2	1	2	2	2	1	1	1	1	2	1	1	
CO-4	2	1	1	3	1	3	3	1	1	0	1	1	1	

UNIT-I

Electrolytic conductance, specific, equivalent and molar conductance, cell constant, conductometric titrations. Theory of potentiometry, calculation electrode potential at the equivalence. Finding of equivalence volume, derivative and linear titration plots. Ion-sensitive electrodes –types of ion sensitive electrodes –metal based cation and anion sensitive electrodes, solid membrane electrodes, glass electrodes. Liquid ion-exchange electrodes, gas sensing membrane electrodes, Electrochemical cell, electrodes: reference and indicator electrodes, membrane electrodes, electrode-solution interface layer, gas-sensing probe, electrolytic process.

[15Hrs]

UNIT-II

Coulometry:

Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, Electrolysis at constant working electrode potential, Coulometric methods of analysis, Faradays laws of electrolysis, Instrumentations-Constant current and constant voltage instruments, potentiostatic coulometry-Instrumentation and applications, coulometric titrations (Amperostatic coulometry)-Apparatus and applications, advantages and limitations, problems.

Electrochemical interfaces – electrical double layer – Lippmann equation, Helmholtz and Gouy – Chapman – Stern models of the double layer, Modern theories of electrical double layer, Adsorption of ions and dipoles. **[15Hrs]**

UNIT-III

Polarography: Polarographic principles, Instrumentation (different types of microelectrode such as dropping mercury electrode, the static drop mercury electrode, rotating disc and ring disc electrode, cell for polarography, reference and counter electrode and circuit diagram), polarogram and polarographic currents, charging or capacitive current, role of supporting electrolyte, factors affecting on polarographic wave, Ilkovic Equation, advantages and disadvantages of DME, polarographic maxima and maxima suppressors, interference due to dissolved oxygen, Applications (qualitative analysis, quantitative analysis by calibration curve and standard addition methods), specific examples of analysis – analysis of Cu, Cd, Zn, Pb, etc. from tap water and alloys. Hydrodynamic voltammetry and applications of hydrodynamic voltammetry: voltametric detectors in chromatography and flow injection analysis, Voltametric oxygen sensor.

[15Hrs]

UNIT-IV

Pulse Polarography: different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, Stripping method. Voltammetry with ultra-microelectrode, Applications of these technique Cu and Zn from tap water by differential pulse polarography and by square wave polarography, Vitamin-C by differential pulse polarography, Determination of Pb in tap water by stripping method) D) Cyclic Voltammetry: Principle of cyclic Voltammetry, cyclic voltammogram of K3[Fe(CN)6], and parathion, criteria of reversibility of electrochemical reactions, quasi- reversible and irreversible processes.

Amperometry:

Principle, Instrumentation, typical applications, amperometric titrations, chrono-amperometry and chrono-potentiometry. **[15Hrs]**

Reference Books:

1) Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987)

2) Instrumental methods of chemical analysis by H. willard, L.Merrit, J.A. Dean and F.A. settle. Sixth edition CBS (1986)

3) Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992) and Principles of Instrumental Analysis Skoog, West, Niemann.

4) Vogel Text Book of quantitative analysis 6 Ed.

5) J. chemical education, 60,302 to 308 (1983)

6) Thermal analysis by W.W. Wendlandt, John Wiley, (1986)

7) Cyclic Voltammetry and frontiers of electrochemistry by N.Noel and K.I. Vasu IBH, New Delhi (1990)
8) Source book of Atomic energy by Glasstone.
9) Principle of Activation Analysis- P. Kruger, John Wiley and sons, (1971).
10) Nuclear Analytical Chemistry – J. Tolgyessy and S. Verga vol. 2, university Park press,(1972)

SEMESTER III –SOFT CORE

Course Code	Duration	Course Title	L	T	P	C
MS17CH354	**16 Weeks**	**ADVANCED ANALYTICAL CHEMISTRY**	**3**	**1**	**0**	**4**

Course Objectives:

1. To understand the separation and extraction of compounds by different methods
2. Exposure to the various analytical techniques for the detection of elements in the solution
3. Highlights and study of instrumental techniques such as Atomic and atomic Spectroscopy
4. Development of sensors, optical, biosensors and their types correlation with basic instrument

Course outcomes:

After completion of this course students will able to;

1. Identification of the elements and their properties by using instrumental methods.
2. Explain the various extraction methods involved during the separation of the compounds.
3. Elaborate the principle, instrumentation and applications of various analytical and spectroscopic techniques.
4. Design the detectable concentration of a given specific analytes

Mapping of Course Outcomes with programme Outcomes (sample)

Course Code	POS / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
	CO 1	3	2	0	2	3	0	0	0	1	2	3	3	3
	CO 2	2	2	1	3	3	2	0	0	1	2	3	2	3
	CO 3	3	3	0	3	3	1	0	0	1	2	4	3	2
	CO 4	4	3	1	3	3	1	0	0	1	2	4	4	3

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.

[15Hrs]

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. **[15Hrs]**

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), Instrumentation for ICPMS, Atomic mass spectra and interferences, Applications of ICPMS.

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. Resonant Ionization Spectroscopy, Laser-enhanced ionization spectroscopy. **[15Hrs]**

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 acoustic wave sensor).

Biosensors in analysis:

Introduction, producing biological surface, Achievement of biotransduction (amperometric, potentiometric, optical). **[15Hrs]**

Reference Books:

1) Introduction to Instrumental Analysis by R. D. Broun, Mc Graw Hill (1987)

2) Instrumental methods of chemical analysis by H. willard, L.Merrit, J.A. Dean and F.A. settle. Sixth edition CBS (1986)

3) Fundamentals of Analytical Chemistry, 6 edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing.

4. Principles of Instrumental Analysis, Skkog, Holler, Nieman, (Sixth Ed.)

5) Vogel's Textbook of Quantitative analysis 6th Ed.

6) Modern analytical techniques in the pharmaceutical and bio analysis By Dr. Istvan Bak (Book Available Online).
7) Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (free e book available on internet)
8) Extraction technique in analytical science, John R. Dean, Wiley (2009)
9) Practical HPLC method Development, Snyder, Kirkiand, Glajch, Wiley India Pvt.Ltd.
10) Standard methods of chemical analysis, Sixth Edition, F.J. Welcher.
11) Quantitative Inorganic Analysis including Elementary Instrumnetal analysis, By A. I. Ed Vogel, 3 , ELBS, 1964.
12) Instrumental methods of analysis, R. D. Braun
13) Analytical Chemistry, Ed. by Kellner, Mermet, otto, Valcarcel, Widmer, Second Ed. Wiley –VCH

SOFTCORE-04

Course Code	Course Title	L	T	P	C	Hrs/Week
M17CH 4024	ADVANCED ELECTROANALYTICAL TECHNIQUES	2	1	0	3	4

Course Objectives: This course aims to provide the student to

a. Knowledge on Electrode types, Electrochemical characterization techniques, Electrochemical STM, Electrochemical AFM, Sensors.
b. Skilled in problem solving, critical thinking and Analytical reasoning as applied to scientific Problems
c. Conclude Fundamental Concepts in Analytical Electrochemistry- Mass transport, Linear diffusion, Fick's laws and diffusion coefficient.
d. Design and carryout scientific experiments as well as accurately record and analyze the results of such experiments

Course Outcomes:

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.

CO3: Explain the Advanced analytical techniques (Sensors) which are useful to analyse the compounds.

CO4; Students will be able to function as a member of an interdisciplinary problem solving.

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**
M18CH4024	**CO 1**	**3**	**1**	**0**	**3**	**2**	**0**	**2**	**2**	**0**	**2**	**2**	**2**	**1**
	CO 2	**2**	**2**	**2**	**3**	**3**	**0**	**1**	**2**	**2**	**3**	**0**	**2**	**2**
	CO 3	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**	**1**	**1**	**2**
	CO 4	**2**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**1**	**2**

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.

[10hr]

UNIT -II

Electrode types, Electrochemical characterization techniques – Cyclic voltammetry, Potentiostatic and galvanostatic methods, Pulse methods, RRDE, impedance analysis.

UNIT -III

Photoelectrochemical measurements, Spectroelectrochemistry, Electrochemical STM, Electrochemical AFM.

UNIT -IV

Electrochemical sensing, Electrochemical biosensors, Electron transfer in DNA and biosystems, Photoelectrochemical sensing.

Reference Books:

10. Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd edition 2001, John Wiley & Sons
11. Allen J. Bard (Ed), Electroanalytical Chemistry, Vol.13, Plenum Press 1983
12. Joseph Wang, Analytical Electrochemistry, 3rd edition 2006, John Wiley & Sons
13. J. Newman, Electrochemical Systems, Wiley-Inter science, 3rd edition 2004

Course Outcomes

INORGANIC CHEMISTRY

Course outcome

- During the study of this course the students will acquire a deeper knowledge about basics in inorganic chemistry periodic properties, solvents, nuclear chemistry etc.

- 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.

- During the study of this course the students will acquire a deeper knowledge complexes, metal ligand interactions about chemistry.

- Student is able to understand various principles of bioinorganic chemistry, Bioenergetics, biophysical chemistry, bioorganic chemistry etc.

- The students are expected to acquire knowledge about inorganic reaction mechanisms and organometallic chemistry.

- 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.

- Student is able to understand different types of solids, its reactions, electronic properties and band theory and gets an information regarding advanced electronic materials.

- Student will be familiar with various spectroscopies like electron spectroscopy, Mossbauer spectroscopy, destructive techniques and non-destructive techniques, SAM, SPM, TEM, LEED etc.

- Students will understand the principles in inorganic photochemistry, metal complexes in drugs, medicinal bioinorganic chemistry and advance nuclear chemistry.

ORGANIC CHEMISTRY

Course Outcome

- The students will acquire knowledge of;

- The structure, nature of bonding in the molecules and reaction mechanism.

- Conformational analysis of cycloalkanes, reactivity, chirality, interconversion, resolution and asymmetric synthesis.

- Organization and working of various components present in living cell.
- Nomenclature of different heterocyclic compounds.

- Synthesis and reactivity five, six and seven membered monocycles and the fused heterocyclic compounds.

- Molecular structure of proteins, DNA, RNA and vitamins, organization and working of various components present in living cell.

- Mechanistic aspects of nucleophilic, electrophilic substitution and elimination reactions.

- Molecular orbital symmetry and possibility of thermally and photochemically pericyclic reactions.
- Conversion of different functional groups via rearrangement reactions.

- Molecular recognition and nature of binding involved in biological systems.

- Structure of supramolecules of various types in solution, solids and their applications in miniaturization of molecular devices.

- Drug designing, development, mode of action of different drugs and role of drugs to inhibit particular enzymes and treatment of disease.

- Mechanistic pathway of organic reactions.

- Retrosynthetic approach of planning organic synthesis

- Conversion of different functional groups via reactions.

- Mechanism of major chemical reactions.

- Utilizing reagents in organic transformations.

- The principles behind Enantio-selectivity and Diastero-selectivity, analyze how stereochemical outcome of the reaction can be predicted.

- Identifying and characterizing various classes of natural products by their structure.

- Appreciate the biogenesis of many natural products of importance.

- 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.

14. ANALYTICAL CHEMISTRY

Course outcomes: After completion, of course students will

15. Acquire knowledge of Data handling/ statistical treatment of data.
16. Acquire knowledge of Potentiometric, Coulometric, and Voltametric methods of analysis, Chromatographic Techniques and applications.
17. Identify and describe the steps that are included in a complete analytical procedure
18. learn the basic analytical and technical skills to work effectively in the various fields of chemistry.
19. To know and understand the issues of safety regulations in the use of chemicals in their laboratory work.
20. Students can define and calculate their tension factor, R f, and describe how TLC and column chromatography can be used for separation and qualitative analysis.

21. This study is useful to furnish students with the advanced technical skills and knowledge base

22. 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.
23. The fundamental analytical techniques, Mass spectrometry, NMR spectroscopy and eclectron spectroscopy.
24. Other general characterisation techniques (IR & UV spectroscopy, mass and NMR spec-troscopy).
25. About spectroscopy and its application in studying the structure of organic molecules.
26. Gain knowledge and understand the principle of Separation techniques, analysis by using spectroscopic techniques.
27. Demonstrate the Chromatographic Techniques and applications.
28. In this practical course the students acquire practical skills related to analytical chemis-try in analysis of constituents present in different samples.
29. The students will acquire knowledge of development of experimental skills on conductivity meter, potentiometer, pH meter and voltammeter for different applications
30. Different concepts of atmosphere, stratospheric and tropospheric chemistry, photochemical smog, acid rain, atmospheric aerosols, global climate.
31. Chemistry of colloids with reference to environment.
32. Air pollution, water pollution, soil pollution and its control.
33. Analysis of various components in food and drug analysis.
34. Concepts and applications of Green Chemistry.
35. Concepts of types of materials, properties of nanomaterials and various preparation methods and characterization techniques like XRD, SEM, TEM, NMR, XPS and applications

36. Concepts of water pollution and water analysis methods

FACULTY PROFILE

Dr. Sakthivel Kandaiah Assistant professor, School of applied sciences, REVA University – Bengaluru holds Ph.D. degree from Max Planck Institute of Solid state Research – Stuttgart, Germany, in the areas of Solid state and electrochemistry under the guidance of Prof. Martin Jansen. He was awarded with Max Planck society research fellowship for his doctoral studies. He has research experience from various reputed institutions in India and abroad i.e. Indian Institute of Science – Bangalore, Indian Institute of Technology-Bombay, Indian Institute of Technology - Delhi, Max Planck Institute - Germany. He has total of 14 years of research and teaching experience. His research interests are in electrochemical energy conversion materials and devices, electrochemical synthesis of novel electrode materials and thin film nanomaterials. Recently he has been awarded with Department of Science and Technology – India Young Scientist Research grant for the project work in the area of nanomaterials for photo-electrochemical hydrogen. He has published his research works in international journals. Also he was involved in introducing new courses in the area of nanoscience and nanotechnology for undergraduate and postgraduate students. His current research focuses are on electrode materials for solar energy conversion devices, Future clean fuel and environmental remediation. His research student is placed in foreign universities for International Ph.D. programmes.

Recent publication under REVA University - Year 2016

- R. S. Vishwanath, Sakthivel Kandaiah*, Chemically Immobilized Triazine Based CuIIS3C3N3 Metallopolymer on Copper as a Photocathode for Photoelectrochemical Hydrogen Evolution, *Journal of The Electrochemical Society*, 163 (6) H402-H409 (2016) 0013-4651/2016/163(6)/H402/8/$33.00 (ECS- USA)

- R. S. Vishwanath, Sakthivel Kandaiah*, Electrochemical preparation of crystalline γ-CuI thin films through potential-controlled anodization of copper and its photoelectrochemical investigations, J Solid State Electrochem (2016) 20:2093–2102,

- R.S. Vishwanath, Sakthivel Kandaiah*, Electrochemical growth of triazine based metal ion containing polymers on nanostructured nickel electrodeposits and their hydrogen evolution activities in acidic condition, In t e r n a t i o n a l journal of hydrogen energy 4 1 (2 0 1 6) 8 829 - 8838,

- R. S. Vishwanath, Sakthivel Kandaiah* Facile electrochemical growth of nanostructured copper phthalocyanine thin film via simultaneous anodic oxidation of copper and dilithium phthalocyanine for photoelectrochemical hydrogen evolution, J Solid State Electrochem (2016) 20:767–773

Dr. Madhusudana Reddy. M. B, is an Associate Professor of Chemistry in School of applied sciences at REVA University, Bangalore, India. He received his M. Sc., Chemistry from the Bangalore University in the year 2003 and Ph. D. for the "Synthesis of biologically important compounds in organic chemistry" from Bangalore University in 2012 under the guidance of Prof. M. A. Pasha. Later he selected for the prestigious Dr. UGC-Kothari Post-doctoral fellowship under the guidance of Prof. P. Balaram, Director at Indian Institute of Science, Bangalore, India, in the area of "Design, synthesis and conformation of hybrid peptides" for three years. Professor Reddy worked as a lecturer in different prestigious colleges for UG and PG about 8 years. His teaching interests are Organic Chemistry, General Chemistry, Inorganic Chemistry, engineering chemistry and Spectroscopy. Professor Reddy's research areas includes: (1) Organic method development using heterogeneous catalysis by metal nanoparticles, nanostructures and nanocomposites, (2) eco-friendly organic synthesis by green chemistry protocols (3) Synthesis and conformation of hybrid peptides and (4) Isolation and characterization of bioactive molecules and peptides from natural sources. He has published 28 International scientific papers that have been well received by the scientific community and participated and presented in 20 national and international conferences.

Dr. Lakshmi.B. is Assistant professor in the in School of applied sciences, REVA University holds M.Sc, in Inorganic chemistry from V.Vpuram College Bangalore University and M.phil from Periyar University, saleum. Phd awarded in chemistry from Bangalore University, in 2011.Post-Doc from Technion-Israel Institute of Technology, Haifa-32000, Israel. She has 11years of teaching experience. She has authored several peer reviewed journals. Her research interests are in the areas of polymers, Chemical Kinetics, Quorum sensing and Advanced Analytical Chemistry.

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Dr .K. Ramakrishna Reddy, Assistant Professor in in School of applied sciences earned his Ph.D degree in Analytical Chemistry from Jawaharlal Nehru Technological University, Anantapur and M.Sc. degree in Physical Chemistry from Sri Krishnadevaraya University, Anantapur. He has published 13 national and International journals and attended two international, four national conferences and two workshops. He has 9 years teaching experience and 6 years research experience. He has taught various subjects at under graduate level viz. Engineering Chemistry, Applied Chemistry, Analytical Chemistry and Physical Chemistry.

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Mrs. MAMATHA MOHAN,

Assistant professor, in School of applied sciences, REVA University holds M.Sc, in Inorganic chemistry from Central College Bangalore University and M.phil from VMU, Tamilnadu. She has 9 years of teaching experience. Her teaching experience include polymer Chemisty, water chemistry, nanomaterials, corrosion science, electrochemistry, solar cell, fuel cells, batteries, chemical fuels and Currently pursuing Ph.D in Bharathiar university . Her area of interest is Bio inorganic chemistry and coordination chemistry, catalysis. She attended 3 workshops in various institutions and presented 3 papers in national conferences.

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Mrs. MANJULA M C, Assistant professor, in School of applied sciences, REVA University, holds M.Sc, in organic chemistry from Bangalore University, Bangalore. She has 7 years of teaching experience. Her teaching experience include polymer Chemistry, water Chemistry, nanomaterials, corrosion science, Electrochemistry, solar cell, fuel cells, batteries, chemical fuels and Her area of interest is Magnetic nano catalyst for organic reactions and currently pursuing Ph.D in Reva university, Bangalore. She attended 3 workshops in various institutions.

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Mr. SREEKANTH R, Assistant Professor in the in School of applied sciences holds M.Sc, in Physical Chemistry from Bengaluru University in the year 1999 and completed M.phil degree with dissertation work entitled "Detection of environmentally hazardous elements" from Sri Krishna Devaraya University, Anantapura, Andhra Pradesh in 2011. Currently pursuing Ph.D in the area of "Transesterification of non-edible oils into Biodiesel using Heterogeneous Catalysts" under VTU, Belagavi. He has put in total 15 years of teaching experience from various institutions.

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Mrs. SHWETHA K R, Assistant professor, in School of applied sciences, REVA University, holds M.Sc, in organic chemistry from Bangalore University, Bangalore. She has 7 years of teaching experience. Her teaching experience include polymer chemisty, water Chemistry, nanomaterials, corrosion science, Electrochemistry, solar cell, fuel cells, batteries, chemical fuels and Her area of interest is Magnetic nano catalyst for organic reactions and currently pursuing Ph.D at REVA University, Bangalore.

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Mrs. PUSHPALATHA R., Assistant professor, in School of applied sciences, REVA University, holds M.Sc, in organic chemistry from Bangalore University, Bangalore in the year 2009. She has 7 years of teaching experience. Her teaching experience include polymer chemisty, water Chemistry, nanomaterials, corrosion science, Electrochemistry, solar cell, fuel cells, batteries, chemical fuels and Her area of interest is preparation of novel compounds via multi component reactions and currently pursuing Ph.D in VTU, Belagavi. She attended 4 workshops in various institutions.

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Ragini.B.S Asst. Professor, in School of applied sciences, holds M.Phill in Vinayaka University, M.Sc. Degree in Chemistry, B.Ed and B.sc. Degree in PCM from Bangalore University. She has 7 years of teaching and practical experience in Chemical science.

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Ms. MUBEENA A., Assistant professor in School of applied sciences, REVA University, holds M.Sc, in organic chemistry from Sri Krishnadevaraya University, Ananthapur in the year 2010. She has 6 years of teaching experience. Her teaching experience include organic, inorganic and spectroscopy. Her area of interest is Magnetic nano catalyst for organic reactions.

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TRAINING AND PLACEMENT

Having a degree or P.G. 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:

- Willingness to learn
- Self-motivation
- Team work
- Communication skills and application of these skills to real scenarios
- Requirement of gathering, design and analysis, development and testing skills
- Analytical and Technical skills
- Computer skills
- Internet searching skills
- Information consolidation and presentation skills
- Role play
- Group discussion, and so on

The 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, Training and Placement (CCTP) Centre headed by well experienced dynamic Trainer, Counselor and Placement Officer supported by an efficient team does handle all aspects of Internships and Placement for the students of REVA University. The prime objective of the CCTP Centre 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 CCTP Centre 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, CCTP Centre 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 Engineering is efficient leaders of repute, who can deal the real time problems with a flavour of innovation. This kept in focus, the Training and Placement cell 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, leadership, and strategic management 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.

Skill development is one of the very important activities of the University and Industry relationship.
A skill development centre is established to organize skill and certification programs. The students shall compulsorily complete at-least two skill/certification based programs before the completion of the 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.

The University has signed MOU's with Multi-National Companies, research institutions, Government agencies like NSDC (National Skill Development Corporation) and universities abroad to facilitate greater opportunities of employability, students' exchange programs for higher learning and for conducting certification programs.

REVA UNIVERSITY

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CALENDER OF EVENTS (JUL - DEC 2017)

PROPOSED SCHEDULE OF TESTS/EXAMINATIONS FOR ENGINEERING COURSES

Sl. No.	Programs	Date of Re-Opening	Dates of									Vacation	Commence-ment of next semester
			IA 1	Results	IA 2	Results	IA 3	Results	Practical Exams	Semester End Exams	Results		
1	B. Tech III, V & VII Sem B.Arch III & V Sem M.Tech - III Sem	27.07.2017	06.09.2017 to 09.09.2017	14.09.2017	23.10.2017 to 26.10.2017	31.10.2017	22.11.2017 to 25.11.2017	30.11.2017	27.11.2017 to 12.12.2017	14.12.2017 to 28.12.2017	06.01.2018	29.12.2017 to 11.01.2018	12.01.2018
2	B.Tech - I Sem B.Arch - I Sem	07.08.2017	20.09.2017 to 23.09.2017	27.09.2017	06.11.2017 to 09.11.2017	15.11.2017	11.12.2017 to 14.12.2017	20.12.2017	18.12.2017 to 27.12.2017	29.12.2017 to 11.01.2018	18.01.2018	12.01.2018 to 23.01.2018	24.01.2018
3	M.Tech - I Sem	21.08.2017	04.10.2017 to 07.10.2017	12.10.2017	22.11.2017 to 25.11.2017	30.11.2017	27.12.2017 to 30.12.2017	04.01.2018	-	04.01.2018 to 15.01.2018	20.01.2018	16.01.2018 to 23.01.2018	24.01.2018

DR.S.Y. KULKARNI
VICE CHANCELLOR
Vice-Chancellor
REVA University, Rukmini Knowledge Park
Kattigenahalli, Yelahanka, Bengaluru-560 064

MSc time table

M. Sc. -Chemistry-TIME TABLE-2017-18

DAY / TIME	8:30to 9:30	9:30 to 10:30	10:30 to 10:50	10:50 to 11:50	11:50 to 12:50	12:50 to1:40	1:40 to 2:35	2:35 to 3:30	3:30 to 4:25
MON	Phy. Chem-Part-A	Analytical Chemistry-A	BREAK	Heterocyclic Chemistry-A	Phy. Chem-Part-B	L	Organic Chemistry-A	Language & Maths	Library
TUE	Heterocyclic Chemistry-	Organic Chemistry-A		Analytical Chemistry-B	Physcical Chemistry Lab/Organic Chemistry Lab				
WED	Inorganic Chemistry-A	Heterocyclic Chemistry		Inorganic Chemistry-A (Tutorial)	Organic Chemistry-B	U	Inorganic Chemistry-B	Heterocyclic Chemistry (Tutorial)	Mentoring
THU	Phy. Chem-Part-A	Analytical Chemistry-B		Inorganic Chemistry-B	Organic Chemistry Lab				
FRI	Organic Chemistry-B	Heterocyclic Chemistry		Phy. Chem-Part-B	NET	NCH	Analytical Chemistry-B (Tutorial)	Phy. Chem-Part-B (Tutorial)	Library
SAT	Analytical Chemistry-A	Organic Chemistry-A (Tutorial)		Inorganic Chemistry-A	R&D, SEMINARS				

DO'S AND DON'TS

DO'S

1. Maintain discipline and respect the rules and regulations of the university
2. Be regular and punctual to classes
3. Study regularly and submit assignments on time
4. Be respectful to your colleagues/friends and hostel staff/management.
5. Read the notice board (both at your college and the hostel) regularly.
6. Utilize your Personal Computer for educational purpose only.
7. Follow the code of conduct.
8. Visit Health Center on the campus whenever you are unwell.

9. Be security conscious and take care of your valuables especially Cash, Mobile Phones, Laptop and other valuables.
10. Carry your valuables along with you whenever you proceed on leave/vacation.
11. Use electric appliances, lights and water optimally.
12. Keep the campus clean and hygienic.

DON'TS

1. Ragging inside / outside the campus.
2. Possession of Fire arms and daggers etc.
3. Use of Alcohols, Toxic drugs, sheesha, gutkha and hashish/heroin etc.
4. Use of Crackers, explosives and ammunition etc.
5. Smoking and keeping any kind of such items.
6. Misusing college & hostel premises/facilities for activities other than studies.
7. Playing loud music in the room which may disturb studies of colleagues / neighbors.
8. Making noise and raising slogans.
9. Keeping electrical appliances, other than authorized ones.
10. Involvement in politics, ethnic, sectarian and other undesirable activities.
11. Proxy in any manner.
12. Use of mobiles in the classrooms.

Note: 1. Rules are revised / reviewed as and when required.

2. Healthy suggestions are welcome for betterment of Institution

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