KANNUR UNIVERSITY

(Abstract)

M Sc Chemistry (Material Science) Programme at Dept.of chemistry, School of Chemical Sciences, Swami Ananda Theertha Campus, Payyanur - Revised Scheme & Syllabus - Approved- Implemented w.e f 2023 admission- Orders Issued

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ACADEMIC C SECTION

ACAD C/ACAD C3/23402/2023 Dated: 17.11.2023

Read:-1. UO No ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
2. Circular No dated ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
3. Email dated 09/11/2023 from the Head, Dept of Statistical Sciences, Mangattuparamba Campus
4. Minutes of the meeting of the Department Council dated 09/11/2023

ORDER

1.The revised Regulations for Post Graduate Programmes under Choice Based Credit and Semester System in the University Teaching Departments/ Schools were implemented w.e.f 2023 admissions vide paper read 1 above

2. As per paper read 2 above, Heads of all Teaching Departments were requested to submit the revised Syllabus in accordance with the approved Regulations along with a copy of the Department Council Minutes.

3. As per paper read 3 above, the Head, Department of Chemistry, School of Chemical science, SAT Campus, Payyanur submitted the Scheme and Syllabus of M.Sc Chemistry (Material Science) Programme to be implemented in the University Teaching Department w.e.f 2023 admissions.

4. Department Council vide the paper read 4 above approved the aforementioned scheme and syllabus of M Sc Chemistry (Material Science) Programme to be implemented in the Dept. of Chemistry at the School of Chemical Sciences of the University w.e.f.2023 admission.

5. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1), Chapter lll of Kannur University Act 1996, ***approved the revised Scheme & Syllabus of M.Sc Chemistry (Material Science) Programme and accorded sanction to implement the same in the Department of Chemistry, School of Chemical Science, SAT Campus, Payyanur, subject to reporting to the Academic Council.***

6.The revised Scheme and Syllabus of M.Sc Chemistry (Material Science) Programme under CBCSS implemented in the Department of Chemistry, School of Chemical Sciences, SAT Campus, Payyanur with effect from 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in)

7. Orders are issued accordingly.

Sd/-
Narayanadas K
DEPUTY REGISTRAR (ACAD)
For REGISTRAR

To: 1. Head, Department of Chemistry, SAT Campus, Payyanur
2. Convenor, Curriculum Committee

Copy To: 1.PS to VC/ PA to PVC/ PA to R
2. To Examination Branch (through PA to CE)
3. EP IV/ EXC I
4. Computer Programmer
5. Webmanager (to publish in the website)
6. SF/DF/FC

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY

Regulation, Scheme and Syllabus

for

M.Sc. PROGRAMME

in

Chemistry

(Material Science)

Choice Based Credit Semester System

(w.e.f 2023 Admission)

School of Chemical Sciences

KANNUR UNIVERSITY

Swami AnathaTheertha Campus

Edat P.O 670327, Kannur

September 2023

M.Sc. DEGREE PROGRAMME *in* CHEMISTRY (MATERIAL SCIENCE)
***under* Choice Based Credit and Semester System**

(Effective from 2023 Admission)

ABOUT THE DEPARTMENT

The School of Chemical Sciences was established in 2002 and is housed at the Payyanur Campus of the University located at Edat, Payyanur. The School is offering M.Sc. Chemistry (Material Science), M.Sc. Nanoscience and Nanotechnology, a joint programme in M.Sc. Chemistry (Nanoscience and Nanotechnology) with MG University Kottayam, Ph.D. in Chemistry and Biochemistry. The pattern of M.Sc. programmes is of Choice Based Credit and Semester System consisting of four semesters including one semester project work. The M.Sc. Chemistry (Material Science) and M.Sc. Chemistry (Nanoscience and Nanotechnology) programmes are equivalent to the M.Sc. Chemistry of Kannur University. The School of Chemical Sciences is having an excellent Library with latest editions of textbooks, reference books and relevant journals in chemistry and material science. Library is also providing internet facility to students. The School of Chemical Sciences has academic collaboration with South Indian Universities such as Mangalore University, Cochin University of Science and Technology, University of Calicut and Central University of Kerala. We also collaborate with National Research Laboratories such as Indian Institute of Science, Bangalore, CSIR-National Chemical Laboratory, Pune, CSIR-Indian Institute of Chemical Technology, Hyderabad, CSIR-Central Leather Research Institute, Chennai, Central Electrochemical Research Institute, Karaikudi, Sri Chitra Tirunal Institute of Medical Science and Technology, Thiruvananthapuram, CSIR-National Institute for Interdisciplanry Science and Technology, Trivandrum and Centre for Materials for Electronics Technology, Thrissur etc.. Fourth semester M.Sc. students carry out their project works in reputed National Institutes

COURSE DETAILS

1	The M.Sc. programme shall be offered in four semesters during a period of two academic years. Each semester will have 17-18 weeks duration. The minimum duration for completion of the programme is four semesters. The maximum period for the completion of the programme is eight semesters.
2	The programme is offered at the School of Chemical Sciences, Swami Anantha Theertha Campus of Kannur University situated at Edat, Payyanur.
3	The programme is based on Choice Based Credit and Semester system. A total of 84 credits shall be the minimum for successful completion of the programme in which a minimum of 58 credits for core courses and 26 credits for electives are mandatory.
4	The number of periods allotted per week for a topic is considered as its credit. For practical, three hours is considered as one credit. Elective courses will be offered depending on the availability of the teaching staff /resource person at that time. At least 10 students have to register for an offered elective course

PROGRAMME DETAILS

1	The first semester consists of four core and one elective course. In the second semester,

	there are 12 Core course and 12 elective corses. Amoung elective courses, two courses (Interdisciplinary and Skill development) courses of 2 credits each should be obtained from from other departments. In the third semester, there are 18 core and 7 elective. Amoung elective courses, The Open Elective courses should be obtained from from other departments. In Fourth semester, there one core course with 12 credits and two elective curses of 3 credits each
2	During the third semester, the students will have to visit an Industry/ Research Institute of National repute. The report of the same may be submitted to the Head of the Department for valuation
3	During the Fourth semester, each student shall carry out project work in any branches of Chemistry/Material Science for a period of not more than six months under the supervision of a teaching staff of the Department nominated by the Head of the Department. The departmental council shall make decisions regarding the project details
4	Attendance is compulsory for each course and the minimum requirement for appearing for the end semester examination shall be as per general regulations of M.Sc. programme of the University
5	One hour per week is allotted for tutorial classes. Each student will be assigned to a teaching staff of the Department as his/her advisor
PROGRAMME OUTCOMES	
PO1	Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives
PO2	Problem Solving: Identify, formulate, conduct investigations, and find solutions to problems based on in-depth knowledge of relevant domains
PO3	Communication: Speak, read, write and listen clearly in person and through electronic media in English/language of the discipline, and make meaning of the world by connecting people, ideas, books, media and technology
PO4	Responsible Citizenship: Demonstrate empathetic social concern, and the ability to act with an informed awareness of issues
PO5	Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them
PO6	Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio- technological changes
PO7	Environmental Sustainability and Global Perspective: Develop an understanding of global standards to foster legal environment. Learn and practice to critically analyze the legal issues from local, national and international concerns
PROGRAMME SPECIFIC OUTCOMES	
PSO1	Gain the knowledge of Chemistry and Material Science through theory and practical experiments

PSO2	Develop the qualities of time management and organization, planning and executing experiments
PSO3	Discover the applications of chemistry in daily life, be able to explain chemical concepts to a non-scientific audience, and apply their knowledge when necessary
PSO4	Acquire the skills necessary to conduct searches in databases and scientific publications, extract the necessary data, and then apply it appropriately
PSO5	Demonstrate proficiency in undertaking individual and/or team-based laboratory investigations using appropriate apparatus and safe laboratory practices.
PSO6	To make the student to have independent research methods in Chemistry/Material Science by accruing hands on experience of passing through a research project in a national reputed institution
PSO7	Demonstrate and apply the fundamental knowledge of the basic principles in various fields of Chemistry
PSO8	To communicate scientific information in a clear and concise manner both orally and in writing
PSO9	To educate and prepare post graduate students to get employment in academic institutes, R & D and Quality control laboratories
PSO10	To provide students with broad theoretical and applied background in all specialization of Chemistry with emphasis on qualitative and quantitative technique

CONTENTS

SEMESTER I

No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
1	MSCHE01 DSC01	Coordination Chemistry (Part I) , Nuclear Chemistry & Organometallic Chemistry	4	-	-	60	40	100	4
2	MSCHE01 DSC02	Equilibrium, Nonequilibrium and Statistical Thermodynamics	4	-	-	60	40	100	4
3	MSCHE01 DSC03	Quantum Chemistry and Chemical Bonding	4	-	-	60	40	100	4
4	MSCHE01 DSC04	Inorganic Chemistry Practical	-	-	12	60	40	100	4

Total for core courses			24					400	16
ELECTIVE COURSES									
5	MSCHE01 DSE01	Conceptual Organic Chemistry	1x3	-	-	60	40	100	3
6	MSCHE01 DSE02	Industrial Chemistry							
7	MSCHE01 DSE03	Environmental Chemistry							
Total			**27**					**500**	**19**
SEMESTER II									
No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
8	MSCHE02 DSC05	Reactive Organic Chemistry	4	-	-	60	40	100	4
9	MSCHE02 DSC06	Analytical Chemistry	4	-	-	60	40	100	4
10	MSCHE02 DSC07	Experimental Organic Chemistry	-	-	12	60	40	100	4
Total for core courses			20					300	12
ELECTIVE COURSES									
11	MSCHE02 DSE04	Coordination Chemistry - (Part II) & Structural Inorganic Chemistry	2x3	-	-	60	40	100	6
12	MSCHE02 DSE05	Group Theory and Spectroscopy							
13	MSCHE02 DSE06	Medicinal Chemistry							
14	MSCHE02 DSE07	Chemical and Electrochemical Energy Systems							

15	MSCHE02 DSE08	Solid State Chemistry							
16	MSCHE02 DSE09	Polymer Chemistry							
INTER- DISCIPLINARY COURSES									
17	MSCHE02 IDC01	Fundamentals of Pharmaceutical Chemistry **(Offered to other Department students)**							
18	MSCHE02 IDC02	Fundamentals of Geochemistry **(Offered to other Department students)**							
19	MSCHE02 IDC03	Biochemistry in Health and Diseases **(Offered to other Department students)**							
-	-----	**(To be obtained from other departments)**	2	-	-	60	40	100	2
SKILL ENHANCEMENTCOURSES									
20	MSCHE02 SEC01	Good Laboratory Practices **(Offered to other Department students)**							
21	MSCHE02 SEC02	Scientific Writing **(Offered to other Department students)**							
22	MSCHE02 SEC03	Separation and Purification Techniques **(Offered to other Department students)**							
-	----	**(To be obtained from other departments)**	2			60	40	100	2
VALUE ADDED COURSE									

23	MSCHE02 VAC01	Advanced Techniques for Characterization of Materials	2			60	40	100*****	2*****
Total			**32**					**600**	**22**
**** Not to be added to the total markjs and credits***									
SEMESTER III									
No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
24	MSCHE03 DSC08	Progressive Organic Chemistry	4	-	-	60	40	100	4
25	MSCHE03 DSC09	Advanced Bioinorganic Chemistry	4	-	-	60	40	100	4
26	MSCHE03 DSC10	Chemical Kinetics and Catalysis	4	-	-	60	40	100	4
27	MSCHE03 DSC11	Physical Chemistry Practical	-	-	12	60	40	100	4
28	MSCHE03 DSC12	Industry Visit	-	-	-	-	100	100	2
Total for core courses			24					500	18
ELECTIVE COURSES									
29	MSCHE03 DSE10	Electro Chemistry, Electrodics and Phase Equilibria	1x3	-	-	60	40	100	3
30	MSCHE03 DSE11	Biomaterials							
31	MSCHE03 DSE12	Forensic Chemistry & Toxicology							
MULTI-DISCIPLINARY ELECTIVE COURSES									
32	MSCHE03 MDC01	Contemporary Chemistry **(Offered to other**							

		Department students)							
-	-------	Multi-disciplinary Elective Course **(To be obtained from other departments)**	4	-	-	60	40	100	4
Total			**32**					**700**	**25**
SEMESTER IV									
No	Course Code	Topic	Contact Hours/week			Marks			Credits
			L	T/S	P	ESE	CE	Total	
CORE COURSES									
33	MSCHE04 DSC13	Research Project		-	30	60	40	100	12
Total for core courses			30					100	12
ELECTIVE COURSES									
34	MSCHE04 DSE13	Inorganic and Nano Materials	2x3	-	-	60	40	100	6
35	MSCHE04 DSE14	Ceramics, Composites and Inorganic Polymers							
36	MSCHE04 DSE15	Advanced Organic Synthesis							
37	MSCHE04 DSE16	Green and Sustainable Chemistry							
38	MSCHE04 DSE17	Advanced Nanomaterial Synthesis							
		Total	**42**					**300**	**18**

Grant Total		
Marks: 2100	**Core Credits: 58**	**Elective Credits: 26**

Course code- MSCHE: Master of Science Chemistry; C: Core; E: Elective; O: Open Course (Hybrid)

Semester I	
Core Course	
Course Code: **MSCHE01DSC01**	Course Name: **Coordination Chemistry (Part I), Nuclear Chemistry & Organometallic Chemistry**

Course Description
Main Group Chemistry research reveals the fundamental Composition, structures, and elemental properties. Acquiring pertinent conceptual and practical information is attainable through this learning. Additionally, the course seeks to assist learners in understanding the bonds, structures, and characteristics of coordination complexes. The discussion of several bonding theories, with a focus on the magnetic and spectral characteristics of coordination complexes, aids in the prediction of the distinctive properties of any transition metal complex. It also assist students to learn about organometallic compounds, which can include metalloids like boron, silicon, and tin as well as alkaline, alkaline earth, and transition metals.

Course Objectives	
1.	To generate the significance of Coordination chemistry, which remains as one of the primary components of Inorganic chemistry.
2.	To understand and apply the concepts and theories of coordination complexes.
3.	To understand the formation and stability of complexes
4.	To realize the critical comparison between V.B, C.F.T and M.O theories.
5.	To generate an idea regarding the structure of the nucleus, different nuclear reactions, methods of measuring radioactivity etc. in terms of modern aspects of nuclear science and induce the students to take up nuclear research in their higher studies.
6.	To understand organometallic compounds including alkaline, alkaline earth, and transition metals, and sometimes broadened to include metalloids like boron, silicon, and tin, as well.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Identify the elements are categorized in the periodic table, including general trends, elemental properties, and structural information.
C02	Interpret the structure and bonding of coordination Complex

C03	Illustrate the shape of coordination complexes using VBT & CFT
C04	Estimate CFSE of any complex and predict low spin/ high spin nature
C05	Demonstrate the basic concepts of Organometallic Compounds including l8 electron rule.
C06	Interpret spectroscopic methods to analyze Organometallic Complexes
C07	Assess the structural characteristics of Organometallic complexes with σ and π bonded ligands.
C08	Differentiate types of nuclear reactions including fission, fusion and decay process.
C09	Compile the various applications of radio activity.
C10	Develop the idea of current techniques in radiochemistry

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Coordination Chemistry - 1**	**18 hrs**
1.1	Introduction to Coordination Chemistry, Types of ligands and complexes. Coordination number and geometry. Isomerism: Geometrical, optical and structural isomerism.	
1.2	Stability of complex ions in aqueous solution: Formation constants. Stepwise and overall formation constants. Factors affecting stability of complexes. Determination of stability constants. Chelate and macrocyclic effects.	
1.3	Theories of Metal Complexes, Valence bond theory and its limitations. Ligand field theory: Splitting of d orbitals in different ligand fields such as octahedral, tetragonal, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields. Jahn-Teller effect. LFSE and its calculation. Thermodynamic effects of LFSE. Factors affecting the splitting parameter. Spectrochemical series.	
1.4	Molecular orbital theory based on group theoretical approach and bonding in metal complexes. MO diagrams of complexes with and without Pi-bonds. Effect of Pi bonding on stability. Nephelauxetic series.	
	Suggested Reading Specific to the module	
1.1	Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel and J. Alexander, John Wiley, 2013.	
1.2	Organometallic Chemistry, RC Mehrotra and A Sing, New Age International	
1.3	Inorganic Chemistry: Principles of Structure and reactivity J. E. Huheey	
1.4	Advanced Inorganic Chemistry F. A. Cotton and G. Wilkinson, Wiley	
2.0	**Nuclear Chemistry**	**18 hrs**
2.1	Nuclear structure, Mass and charge, Binding energy, Nuclear stability, Magic numbers, Nuclear moments, Magnetic properties of nucleus	
2.2	Nuclear models: Shell, Liquid drop, Fermi gas, Collective and optical models, Radioactive equilibrium, Transient and secular equilibria	
2.3	Nuclear reactions: Q-value, Semi empirical mass equation, Types of nuclear	

	reactions, Spontaneous and induced nuclear fission.
2.4	Reaction cross section and critical size, Nuclear fusion, Stellar energy. Nuclear energy in India.
Suggested Reading Specific to the module	
2.1	Essentials of Nuclear Chemistry, H. J. Arnikar, New Age International, 1981
2.2	Elements of Nuclear Chemistry, Elements of Nuclear Chemistry, R. Goplalan, Vikas Publishers, 2000
2.3	Introduction to Radiochemistry G. Friedlander and J. W. Kennedy, John Wiley and Sons
2.4	Essentials of Nuclear Chemistry, H. J. Arnikar, New Age International, 1981
3.0	**Radiation Chemistry 18 hrs**
3.1	Detection and measurement of radioactivity: Principle and working of GM
3.2	Interaction of gamma radiation with matter:Effects of radiation on the structure and stability of solids
3.3	Applications of radioactivity: Tracer techniques
3.4	Detection and measurement of radioactivity: Principle and working of GM
Suggested Reading Specific to the module	
3.1	Elements of Nuclear Chemistry, R. Gopalan, Vikas Publishers, 2000
3.2	Essentials of Nuclear Chemistry, H. J. Arnikar, New Age International, 1981
3.3	Introduction to Radiochemistry, G. Friedlander and J. W. Kennedy, John Wiley and Sons.
3.4	Nuclear Chemistry C V Shekar, Dominent Publishers
4.0	**Organometallic Chemistry 18 hrs**
4.1	Transition metal alkyls and aryls, routes of synthesis, stability and decomposition pathways, organo copper in organic synthesis
4.2	Transition metals to carbon multiple bonded compounds, alkylidenes, alkylidynes, low valent carbenes and carbynes synthesis, nature of bond, structural characteristics and reactivity (electrophilic and nucleophilic reactions on the ligands).
4.3	Transition metal-π complexes with unsaturated organic molecules: alkenes, alkynes, allyl, diene, dienyl, arene, and trienyl complexes, fluxionality and dynamic equilibria in compounds such as η^2 – olefin, η^3 – allyl and dienyl complexes
4.4	Catalysis by organometallic compounds: hydrogenation, hydroformylation , Monasanto Acetic Acid, Wacker process and polymerization reactions.
Suggested Reading Specific to the module	
4.1	Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel and J. Alexander, John Wiley, 2013.
4.2	Inorganic Chemistry: Principles of Structure and reactivity J. E. Huheey, Harper Collins
4.3	Inorganic Chemistry, A.G. Sharpe, Pearson Education, 2012
4.4	Organometallic Chemistry, R C Mehrotra and A Singh, New Age International.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Nuclear Chemistry, C. V. Shekar, Dominant Publishers, 2014
2. Radiochemistry and Nuclear Chemistry, G. R. Choppin, J-O. Liljenzin and J. Rydberg, Academic Press, 2013
3. Sourcebook on Atomic Energy, S. Glasstone, Van Nostrand, 1958.
4. Essentials of Nuclear Chemistry, H. J. Arnikar, New Age International, 1981
5. Nuclear Chemistry – Through Problems, H. J. Arnikar and N. S. Rajukar, New Age International, 2007.
6. Elements of Nuclear Chemistry, R. Goplalan, Vikas Publishers, 2000.
7. Introduction to Radiochemistry, G. Friedlander and J. W. Kennedy, John Wiley and Sons.
8. Advanced Inorganic Chemistry F. A. Cotton and G. Wilkinson, Wiley.
9. Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel and J. Alexander, John Wiley, 2013.
10. Inorganic Chemistry, Shriver and Atkins, Oxford University Press, 1999.
11. Organometallic Chemistry, R C Mehrotra and A Singh, New Age International.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Inorganic Chemistry, K. F. Purcell and J. C. Kotz, Cengage Learning, 2010.
2. Coordination Chemistry, S.F.A Kettle, Longman
3. Modern Coordination Chemistry ,E.Lewis and R.G Wilkins (Eds) Interscience.
4. Theoretical Inorganic Chemistry, M C Day and J Selbin, Affiliated East West Press.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Illustrate one method for the determination of stability constant.
2. Write down the basis of Fermi gas nuclear model.
3. Compare various nuclear models emphasizing the merits demerits of one over the other.
4. Explain the term stellar energy?
5. Describe the principle and working of scintillation counters.

Semester I	
Core Course	
Course Code: **MSCHE01DSC02**	Course Name: **Equilibrium, Nonequilibrium and Statistical Thermodynamics**

Course Description
With a focus on the concepts of systems, states, and processes, this course exposes students to the fundamentals of physical chemistry. Themes addressed include statistical mechanics, classical thermodynamics, and quantum mechanics. The connection between physical occurrences and the molecular structure and interactions that underlie them will be emphasized throughout the course.

Course Objectives	
1.	Understand a comprehensive and rigorous treatment of classical thermodynamics
2.	State and apply basic concepts of thermodynamics into mixtures, Understand thermodynamics of ideal and non-ideal solutions.
3.	Find the connection between statistics and thermodynamics and differentiate between different ensemble theories used to explain the behaviour of the systems.
4.	To understand the properties of macroscopic systems using the knowledge of the properties of individual particles, thermodynamic probability, macroscopic and microscopic states

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Correlate thermodynamic properties and apply them in systems. Judge the degrees of freedom of systems and understand theories of irreversible thermodynamic systems. Achieve basic skills required to derive thermodynamic properties. Has thorough knowledge on different classical and quantum mechanical distribution functions Can explain the procedures for deriving the relation between thermodynamic parameters such as pressure, temperature, entropy and heat capacity from the distribution functions.
C02	Give an account of the relevant quantities used to describe macroscopic systems, thermodynamic potentials and ensembles.

C03	Give an account of the theory of statistical mechanics and the approximations making a statistical description possible
C04	Show an analytic ability to solve problems relevant to statistical mechanics
C05	Apply the theory to understand gases and crystals and in addition be able to construct microscopic models and from these derive thermodynamic observables

Course outcomes based on revised Blooms taxonomy

Module	**Course Contents**	**No. of hrs**
1.0	**Classical Thermodynamics**	**24 hrs**
1.1	Nernst Heat theorem, apparent exception to third law, application of third law, Absolute entropy, residual entropy	
1.2	Henry's Law, Maxwell relation and significance, Thermodynamic of partial derivative by Jacobians method, Euler's relation	
1.3	Thermodynamic equation of state, partial molar quantities, chemical potential and other thermodynamic functions	
1.4	Thermodynamics of mixing, Gibbs-Duhem-Margules equation, Lewis-Rrandall rule	
1.5	Fugacity in liquid mixtures, chemical affinity and other thermodynamic functions, excess thermodynamics properties	
Suggested Reading Specific to the module		
1.1	An Introduction to Chemical Thermodynamics, RP Rastogi, R R Misra, Vikas publication	
1.2	Thermodynamics for Chemist, Samuel Glasttone, East West Publishers	
1.3	Physical Chemistry, Levine, Molecular thermodynamics, McQuarrie, Donald A.	
1.4	Fundamentals of thermodynamics, Sonntag, Richard.E, Wiley	
1.5	Thermodynamics and statistical mechanics, Devesh Kumar Dixit, Random Publishers	
2.0	**Irreversible Thermodynamics**	**12hrs**
2.1	Thermodynamics of irreversible process, simple examples,	
2.2	General theory of non-equilibrium process	
2.3	Entropy production from heat flow, matter flow	
2.4	Entropy production from current flow and chemical reaction, Phenomenological relations.	
Suggested Reading Specific to the module		
2.1	An Introduction to Chemical Thermodynamics, RP Rastogi, R R Misra, Vikas publication	
2.2	Thermodynamics for Chemist, Samuel Glasttone, East West Publishers	
2.3	Introduction to Thermodynamics of Irreversible Processes, I. Prigogine, Cambridge University Press	
2.4	Non-equilibrium Thermodynamics, Sybren Ruurds de Groot, Peter Mazur,	

	Dover Publications
3.0	**Statistical Thermodynamic - I 18 hrs**
3.1	Basic principles, permutation, probability concept, thermodynamic probability, macrostates and microstates, derivation of Boltzman distribution law.
3.2	Partition function, physical significance, different ensembles, distinguishable and Indistinguishable molecules, partition function and thermodynamic function.
3.3	Separation of partition functions, translational, rotational, vibrational and electronic partition functions.
3.4	Calculations of thermodynamic functions and equilibrium constants, equation of state, Sackur-Tetrode equation, statistical formulation of third law of thermodynamics.
Suggested Reading Specific to the module	
3.1	A course on statistical thermodynamic, Kistin and Dorfuran- Academic 19
3.2	Elements of statistical Thermodynamics, L.K. Nash- Addision Wesley Publishing
3.3	Elements of statistical Thermodynamics, M.C.Gupta- New age international.
3.4	Principle of Physical Chemistry, Puri Sharma Pathania
4.0	**Statistical Thermodynamics-II 18 hrs**
4.1	Basic idea of phase-space, heat capacity of gases, heat capacity of Hydrogen, ortho and para Hydrogens.
4.2	The atomic crystals: Einstein's theory of atomic crystal, Debye's modification of Einstein's model, The virial expression and virial coefficient, relation between virial coefficient and the cluster integrals
4.3	Need for quantum statistics, Bose-Einstein statistics, Bose-Einstein distribution, theory of paramagnetism, Bose-Einstein condensation, liquid Helium, super cooled liquids
4.4	Fermi-Dirac distribution, application of free electron gas, thermionic emission, comparison of three statistics.
Suggested Reading Specific to the module	
4.1	A course on statistical thermodynamic, Kistin and Dorfuran- Academic 19
4.2	Elements of statistical Thermodynamics, L.K. Nash- Addision Wesley Publishing
4.3	Elements of statistical Thermodynamics, M.C.Gupta- New age international.
4.4	McQuarrie, Donald A. (1975). Statistical mechanics. New York: Harper & Row.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. A course on statistical thermodynamic, Kistin and Dorfuran- Academic 1971.
2. Elements of statistical Thermodynamics, L.K. Nash- Addision Wesley Publishing
3. Elements of statistical Thermodynamics, M.C. Gupta- New age international.
4. An Introduction to Chemical Thermodynamics, RP Rastogi, R R Misra, Vikas publication
5. Thermodynamics for Chemist, Samuel Glasttone

6. Physical Chemistry by Puri and Sharma
7. Thermodynamics and statistical mechanics, by Attard,Phil
8. Molecular thermodynamics by McQuarrie, Donald A.
9. Fundamentals of thermodynamics by Sonntag,Richard.E

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Statistical thermodynamic, D.A. Mc Quarrie- Harper and Row
2. Introduction to Thermodynamics of Irreversible Processes, I. Prigogine

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Give the influence of temperature and pressure on chemical potential.
2. Define forces and fluxes with reference to the irreversible processes
3. State and explain 'Onsager Reciprocal' relation.
4. Define partion function. Expain its significance
5. Explain the relationship between partition function and entropy of the system

Semester I	
Core Course	
Course Code: **MSCHE01DSC03**	Course Name: **Quantum Chemistry and Chemical bonding**

Course Description
The understanding of chemical phenomena at the microscopic level requires a knowledge of the principles of quantum mechanics. This course deals with the fundamental principles of quantum theory and their application to the atomic and molecular systems. The course is divided into four modules. The first modules discuss about the failures of classical mechanics, historical background of quantum mechanics and quantum mechanical treatment of simple systems. The second module deals with the quantum mechanical treatment of hydrogen-like atoms and the different approximate methods in quantum chemistry. Molecular orbital treatment of various homo and heteronuclear diatomic molecules are discussed in third

module. Fourth module deals with HMO theory of linear conjugated systems and hybridization & geometry of molecules.

Course Objectives	
1.	To understand atomic and molecular structure, as well as its properties.
2.	To introduce the postulates of quantum mechanics and apply to simple systems.
3.	To understand the concept of the uncertainty principle and interpret the wave functions as a probability density.
4.	To provide an introduction to the mathematical foundations of quantum chemistry.
5.	To explore the application of quantum mechanics to understand the chemical phenomena with special emphasis on chemical structure and bonding

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Apply the postulates of quantum mechanics and solve the Schrödinger equations for simple systems such as the particle-in-a-box, harmonic oscillator, rigid rotor, and hydrogenic atoms.
C02	Derive the variational principle and use it to calculate properties for simple systems
C03	Use perturbation theory to calculate properties for simple systems
C04	Explain the quantum mechanical treatment of the chemical bonds in homonuclear and heteronuclear diatomic molecules
C05	Explain hybridization and geometry of molecules using modern quantum mechanical theories

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Quantum chemistry – I**	**18 hrs**
1.1	Classical mechanics and its limitations – need of quantum mechanics, Max Planck's quantum theory of radiation, Heisenberg's uncertainty principle	
1.2	Schrodinger wave mechanics, physical meaning of wave function, well behaved functions, orthonormality of wave functions.	
1.3	Elements of operator algebra, Eigen functions and Eigen values, Hermitian operators, the postulates of quantum mechanics, time dependent and time independent Schrodinger equations.	

1.4	Quantum mechanics of translational motion, particle in a one and three-dimensional boxes, degeneracy
1.5	Quantum mechanics of vibrational motion, one-dimensional harmonic oscillator, comparison of classical and quantum mechanical results.
1.6	Quantum mechanics of rotational motion, particle on a ring-rigid rotator, the wave function in spherical polar co-ordinates. Legendre polynomials, spherical harmonics, polar diagrams
Suggested Reading Specific to the module	
1.1	Introductory Quantum chemistry, A.K. Chandra, Tata McGraw Hill.
1.2	Quantum chemistry, R K Prasad, New Age International
1.3	Quantum chemistry, D.A. McQuarrie, University Science Books.
1.4	Introduction to Quantum Mechanics, L. Pauling and W.B. Wilson, McGraw Hill
1.5	Molecular Quantum Mechanics, P.W. Atkins, R.S. Friedmann, Oxford University Press.
1.6	Quantum chemistry, I. N. Levine, Pearson Education
2.0	**Quantum chemistry- II 18 hrs**
2.1	Quantum mechanics and potential energy of Hydrogen like atoms, the wave equation in spherical polar coordinates, solution of the R, θ, Ø equations.
2.2	Need of approximate methods in quantum chemistry, variation method, ground states of Hydrogen and Helium atoms, perturbation method, ground state of Helium atom.
2.3	Electron spin and atomic structure, spin functions and operators, Pauli's exclusion principle, Slater determinantal wave functions, spin orbit interactions.
2.4	Quantization of angular momentum, quantum mechanical operators corresponding to angular momentum in polar coordinates, Russel-Saunders terms and coupling schemes.
Suggested Reading Specific to the module	
2.1	Quantum chemistry, R K Prasad, New Age International
2.2	Introductory Quantum chemistry, A.K. Chandra, Tata McGraw Hill.
2.3	Quantum chemistry, D.A. McQuarrie, University Science Books.
2.4	Introduction to Quantum Mechanics, L. Pauling and W.B. Wilson, McGraw Hill
3.0	**Chemical Bonding – I 18 hrs**
3.1	Born-Oppenheimer approximation, essential principles of the MO method, MO treatment of Hydrogen molecule and the H_2^+ ion.
3.2	Valence bond treatment of ground state of hydrogen molecule, MO treatment of homonuclear diatomic molecules, Li_2, Be_2, N_2, O_2, O_2^+, O_2^-, F_2 and heteronuclear diatomics, LiH, CO, NO, HF.
3.3	Correlation diagrams, non-crossing rules, spectroscopic term symbols for diatomic molecules.
3.4	Theorems in chemical bonding: The Virial theorem, The Hellmann – Feynman

	theorem.
Suggested Reading Specific to the module	
3.1	Molecular Quantum Mechanics, P.W. Atkins, R.S. Friedmann, Oxford University Press.
3.2	Quantum chemistry, I. N. Levine, Pearson Education
3.3	Computational Methods in the Chemical Sciences, A.F. Carley and P.H. Morgan, Eillis Horwood
3.4	Molecular Quantum Mechanics, P.W. Atkins, R.S. Friedmann, Oxford University Press.
4.0	**Chemical Bonding – II 18 hrs**
4.1	Theory of directed valency, hybridization and geometry of molecules (methane, water, ethane, acetylene).
4.2	HMO theory of linear conjugated systems (ethylene, allyl systems, butadiene) and its bond order, charge density and free valency calculations
4.3	HMO theory of cyclic conjugated systems (cyclobutadiene, benzene)
4.4	Introduction to metallic bonding, introduction to hydrogen bonding.
Suggested Reading Specific to the module	
4.1	Fundamentals of Quantum chemistry, R Anantharaman, Macmillan.
4.2	Molecular Quantum Mechanics, P.W. Atkins, R.S. Friedmann, Oxford University Press.
4.3	Quantum chemistry, I. N. Levine, Pearson Education
4.4	Computational Methods in the Chemical Sciences, A.F. Carley and P.H. Morgan, Eillis Horwood

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Fundamentals of Quantum chemistry, R Anantharaman, Macmillan.
2. Introduction to Quantum Mechanics, L. Pauling and W.B. Wilson, McGraw Hill.
3. Introductory Quantum chemistry, A.K. Chandra, Tata McGraw Hill.
4. Quantum chemistry, D.A. McQuarrie, University Science Books.
5. Quantum chemistry, R K Prasad, New Age International
6. Theoretical Inorganic Chemistry, M. S. Day and J. Selbin.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Quantum Chemistry and Spectroscopy. Engel, Pearson Education.
2. Quantum Chemistry and Spectroscopy M.S. Pathania, (Problems & Solutions), Vishal Publications.
3. Quantum Mechanics in Chemistry, M. W. Hanna, Benjamin, 3rd Edn.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Discuss the postulates of Quantum Mechanics.
2. Find the slater determinant wave function for ground state of Helium atom.
3. Use Hund's rules to determine the lowest energy states of the ground states of Boron and Fluorine atoms.
4. Explain LCAO method of bonding in hydrogen molecule.
5. Explain the hybridization in water molecule and estimate the bond angles.

Semester I	
Core Course	
Course Code: **MSCHE01DSC04**	Course Name: **Inorganic Chemistry Practical**

Course Description
The course is divided into four modules. Each module describes different but related concepts in inorganic chemistry. The basics of inorganic chemistry such as volumetric, gravimetric, colorimetric and electro analytical methods are included. Separation and identification of four metal ions as well as analysis of some typical ores and alloys are also included.

Course Objectives	
1.	To explore the basic chemistry in aqueous medium, solubility product, color, texture, solubility, group chemistry etc. of mixture some rare earth and common inorganic salts.(cations only)
2.	To explore the chemistry of complex formation and their stability.
3.	To apply the principle and application of Beer Lambert's law.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
-	4	4	-	12	12	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	Detect the cations present in unknown inorganic sample.
C02	Expertise in complexometric titrations will help the students to analyze the water quality parameters such as hardness and also in their future research.
C03	Expertise in colorimetric experiments will be much useful for the students in their future research for handling similar advanced equipment.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of Hrs
1.0	**Mixture separation**	**54 hrs**
	Separation and identification of four metal ions of which two are rare/less familiar such as T1, W, V, Se, Te, Ti, Ce, Th, Zr, U, Mo and Li. (6 Experiments)	
	Suggested Reading Specific to the module	
1.0	A Text Book of Quantitative Inorganic Analysis, A.I.Vogel, Longman	
2.0	**Volumetric estimations**	**40 hrs**
2.1	Estimations using EDTA- Ca, Cu, Fe, Ni, Co, (4 Nos.)	
	Suggested Reading Specific to the module	
2.1	Experimental Inorganic Chemistry, W.G. Palmer.	
3.0	**Colorimetric determinations & estimation of binary mixtures**	**68 hrs**
3.1	Colorimetric determinations of Cr, Fe, Ni and Mn. (4 Nos.).	
3.2	Estimation of binary mixtures of metal ions in solution by volumetric, gravimetric, colorimetric and electro analytical methods for the following Cu, Ni, Fe, Zn, Mg, Ca, Ba, $Cr_2O_7^{2-}$ etc.	
3.3	Preparation of complexes.	
3.4	Colorimetric determinations of Cr, Fe, Ni and Mn. (4 Nos.).	
	Suggested Reading Specific to the module	
3.1	A Text Book of Quantitative Inorganic Analysis, A.I.Vogel, Longman	
3.2	Experimental Inorganic Chemistry, W.G. Palmer.	
3.3	Quantitative Chemical Analysis, I.M. Kolthoff and E.M. Sanderson	
3.4	A Text Book of Quantitative Inorganic Analysis, A.I.Vogel, Longman	
4.0	**Analysis of ores/alloys and separation of binary mixtures**	**54 hrs**
4.1	Analysis of some typical ores and alloys.	
4.2	Ion exchange separation of binary mixtures of metal ions.	
4.3	NPK estimation and pH determination of soil and fertilizer.	
4.4	Analysis of some typical ores and alloys.	
	Suggested Reading Specific to the module	
4.1	Analysis of Minerals and Ores of Rare Elements, W.R.Schoder and A.R. Powell	
4.2	Experimental Inorganic Chemistry, W.G. Palmer	
4.3	Quantitative Chemical Analysis, D. Levie, Tata Mc Graw Hill	
4.4	Hand Book of Preparative Inorganic Chemistry –Vol I & II, G. Brauer	

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. A Text Book of Quantitative Inorganic Analysis, A.I.Vogel, Longman
2. Analysis of Minerals and Ores of Rare Elements, W.R.Schoder and A.R. Powell
3. Preparative Inorganic Reactions N.L. Jolly (Ed)
4. Quantitative Chemical Analysis, I.M. Kolthoff and E.M. Sanderson
5. Analysis of Minerals and Ores of Rare Elements, W.R.Schoder and A.R. Powell

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Semimicro Qualitative analysis, Ramanujam.
2. Vogel's Qualitative Inorganic Analysis, Svehla, Pearson Education
3. Vogel's Textbook of Quantitative Chemical Analysis, Menham, Pearson Education

Teaching Learning Strategies

- Practical, Viva Voce

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Write down the principle for the estimation of Calcium Complexometry.
2. Write down the procedure to estimate the amount of iron by colorimetry
3. Give the spot test for Tungston and explain the theory behind it.
4. What is the principle behind the separation of mixture analysis?

Semester I	
Elective Course	
Course Code: **MSCHE01DSE01**	Course Name: **Conceptual Organic Chemistry**

Course Description
The course is divided into four modules. Each module describes different but related concepts in organic chemistry. The basics of organic chemistry such as aromaticity, Huckel orbitals and Hammett plots are elaborately considered. Structure, formation and reactivities of reactions intermediates such as carbanions, carbocations, carbenes, etc are included. The basic aspects of stereochemistry and introduction to advanced stereochemistry are depicted in the third module. Concepts of green synthetic strategy and the use of various methods in organic synthesis for the implementation of the same is also discussed.

Course Objectives	
1.	To predict and explain patterns of the theory of organic chemistry
2.	To understand and apply the concepts of organic chemical structure
3.	To learn the bonding and stability of organic molecules
4.	To have an idea of stereochemistry, and its applications
5.	To learn the reactions based on green chemical aspects

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	explain localized and delocalized chemical bondings, resonance, bond energy, polarizabilty, MOT, HMOT, aromaticity, anti, homo, non,- aromaticities, aromaticity of heterocycle rings, fused rings, charged rings and annulenes
C02	apply thermodynamics and kinetics of organic reactions, Hammet plots and limitations of and deviations from Hammet plots. Electronic and steric effects. Influence of structural features on acidity, basicity and reactivity of organic compounds
C03	illustrate classical and non-classical carbocations, chemistry of enolates and enamines, addition and insertion reactions, rearrangement reactions of carbenes
C04	explain the reactivity in acyclic compounds. Stereochemistry of organic compounds other than carbon centre, enantiomeric and diastereomeric excess, stereochemistry of cyclohexane, fused rings and bridged compounds
C05	apply optical rotation and optical rotatory dispersion, circular dichroism, Cotton effect and their application in assigning configuration and conformation, octant and axial haloketone rules
C06	learn the importance of minimizing waste, saving power and doing organic synthesis according to the principles of green chemistry
C07	create awareness for reducing waste, minimizing energy consumption in organic synthesis

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	
1.0	**Theoretical Organic Chemistry**	**14 hrs**
1.1	Localized and delocalized chemical bondings, resonance, bond energy, polarizabilty,	

1.2	Molecular Orbital Theory, Huckel MOT, Its assumptions, limitations and applications.
1.3	Aromaticity- Types of aromaticities – anti- aromaticity, homo-aromaticity, non-aromaticity. Examples and comparison of properties,
1.4	Aromaticity of four, five and six membered heterocyclic compounds, fused rings, charged rings and annulenes.
1.5	Hammett equation and plots –Limitations of and deviations from Hammet plots, Significance and applications of Hammett plots
1.6	Electronic and steric effects. Influence of structural features on acidity, basicity and reactivity of organic compounds
Suggested Reading Specific to the module	
1.1	A Guidebook to Mechanisms in Organic Chemistry, P. Sykes, Pearson Education
1.2	The Search of organic reaction pathways, P. Sykes, John Wiley & Sons
1.3	Organic Chemistry, P. Y. Brice, Pearson Education
1.4	Organic Chemistry Vol. I (Sixth Edn.) and Vol. II (Fifth Ed.,) by I L Finar, Pearson Education
1.5	Organic Chemistry (fifth Edn.,) Robert Thronton Morrison, Robert Neilson Boyd, S.K Bhattacharjee, Pearson Education
1.6	Advanced Organic Chemistry: Part A: Structure and Mechanisms, Francis A. Carey, Richard J. Sundberg, Springer
2.0	**Reactive intermediates 14 hrs**
2.1	Carbocations: Generation, structure, detection, stability and reactions of carbocations, Classical and non-classical carbocations.
2.2	Carbanions: Geometry, occurrence and properties of carbanions, factors affecting the stability of carbanions, main reactions of carbanions, carbon acids
2.3	Radicals: Carbon free radicals: Generation, stability and reactions of radicals
2.4	Diradicals: Structure and generation of carbenes, addition and insertion reactions and rearrangement reactions of carbenes. Structure of nitrene, generation and reactions of nitrene
2.5	Formation and reactions of benzynes, chemistry of enolates and enamines
Suggested Reading Specific to the module	
2.1	Mechanism and theory in organic chemistry, H. Lowry and K. S. Richardson, Second edition, Harper & Row, New York, 1981
2.2	Modern methods of Organic Synthesis, Carruthers and I. Coldham, First South Asian Edition 2005, Cambridge University Press
2.3	Organic Chemistry, Leroy G. Wade, Pearson Education
2.4	Organic Synthesis, Michael B Smith, 2nd Edition, 2005
2.5	Principles of Organic Chemistry, T. A. Geissman, W.H. Freeman & Co Ltd; 4th edition,1977
3.0	**Stereochemistry 13 hrs**

3.1	Introduction to isomerism: Chirality of molecules devoid of chiral centres:, restricted rotation and asymmetry, Atrop isomerism. Molecules with planar chirality: annulenes, enantiomeric and diastereomeric excess.
3.2	Reactivity in acyclic compounds, stereochemistry of cycloalkanes and cyclohexane, fused rings and bridged compounds
3.3	Cram-Chelate, Felkin-Ahn, anti-Felkin, Houk models, Cieplak and cation coordination models. Stereochemistry of allenes, spirans, metallocenes and helicenes
3.4	Stereo selective synthesis, asymmetric synthesis, chiral auxiliaries, methods of asymmetric induction. Stereochemistry of organic compounds other than carbon centre
3.5	Introduction to optical rotation and optical rotatory dispersion, circular dichroism, Cotton effect and their application in assigning configuration and conformation, octant and axial haloketone rules
Suggested Reading Specific to the module	
3.1	Stereochemistry of carbon compounds, Ernest Eliel, Tata Mc Graw Hill, 2001
3.2	Introduction to stereochemistry, K. Mislow, Dower Publications
3.3	Organic stereochemistry, M.J.T. Robinson, Oxford Publications
3.4	Introduction To Stereochemistry, Andrew Clark, RSC publications
3.5	Dynamic Stereochemistry of Chiral Compounds Principles and Applications, Christian Wolf, RSC publications
4.0	**Methods of Organic Synthesis 13 hrs**
4.1	Applications of the Green strategies in organic synthesis, Definition, need for Green chemistry, evolution of Green Chemistry, principles of Green Chemistry. Classification of organic reactions under Green chemistry principles
4.2	Atom economic and non-toxic byproduct reactions: rearrangements, Alternative/Green Solvents for Organic Synthesis, Water, Ionic liquids, Supercritical liquids and PEG.
4.3	Microwave assisted organic synthesis, examples, advantages and disadvantages, Phase transfer catalysis, Synthesis and synthetic applications of crown ethers
4.4	Protective groups in organic synthesis, protection of hydroxyl, carboxyl, carbonyl, amino groups. Protection of carbon-carbon multiple bonds. Illustration of protection and deprotection in synthesis
4.5	Organic reaction pathways, factors affecting the reaction yields, design of reaction conditions, solvents and apparatus, monitoring of reactions, Thin layer chromatography, search of solvent combinations and ratio, purification, methods for determination of reaction mechanism
Suggested Reading Specific to the module	
4.1	Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner, Oxford University Press, Oxford, 1998

4.2	Green Chemistry: An introductory text by Mike Lancaster, RSC publishing, 2nd Edition, 2010
4.3	Phase Transfer Catalysis in Organic Synthesis, William P. Weber, George W. Gokel, Springer - Verlag
4.4	Organic synthesis: special techniques, V.K. Ahluwalia and R. Agagrwal, Narosa
4.5	Introduction To Strategies for Organic Synthesis, Starkey L S, John Wiley and Sons

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Principles of organic Synthesis, R.O.C Norman, J.M.C. Frnsz, ELBS
2 Organic stereochemistry, M.J.T. Robinson, Oxford Publications
3 Physical Organic Chemistry, Jack S. Hine. Mc Graw Hill
4 Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, London, 1976
5 Stereochemistry of organic compounds, Ernest L. Eliel (Author), Samuel H. Wilen, Wiley
6 Isochorismate Pyruvate Lyase: A Pericyclic Reaction Mechanism? Michael S. DeClue, Kim K. Baldridge, Dominik E. Künzler, Peter Kast, and Donald Hilvert J. Am. Chem. Soc.; 2005; 127(43) pp 15002 - 15003;
7 Reactions Rearrangements and Reagents, S N Sanyal, Bharati Bhawan Publishers & Distributors

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Advanced Organic Chemistry, Jerry March, Wiley Inter-science
2. Organic Chemistry, Jonathan Clayden, Stuart Warren, Nick Greeves, Oxford University Press
3. Organic Chemistry, T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder, Wiley
4 Blanksby, S. J.; Bowie, J. H. (2005). "Carbanions: formation, structure and thermochemistry". The encyclopedia of mass spectrometry. Gross, Michael L., Caprioli, R.M. (1st ed.). Amsterdam: Elsevier.
5 Steric and Stereoelectronic Effects in Organic Chemistry, V. K. Yadav, Springer, 2016
6 Green Chemistry: Environment Friendly Alternatives by Rashmi Sanghi and M M Srivastava, Narosa Publishing House, Delhi, 2003
7 Organic Chemistry Reactions and Reagents, O.P Agarwal, Krishna Prakashan Publishers
8 Organic Reaction Mechanisms, A Step by Step Approach, Michael Edenborough, CRC press.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Explain Huckel MOT and its limitations.
2. Discuss the deviations from Hammett plot
3. Discuss the various factors affecting the stability of carbocations?
4. 'Benzynes are highly reactiove' Suggest some of their reactions
5. Describe asymmetric synthesis and its importance
6. Discuss Cotton effect and its applications
7. Explain the main principles of green chemistry
8. Describe the microwave assisted organic reactions

Semester I	
Elective Course	
Course Code: **MSCHE01DSE02**	Course Name: **Industrial Chemistry**

Course Description
Contents of the course include the need and requirements of industrialization, the pilot planting and design of its apparatus. The industrialization of four main and important areas and their chemistry are included. They are, the pharmaceutical, the battery, the fertilizers and the polymer industries. Manufacturing of representative commodities like Paracetamol, urea, etc are elaborately discussed. The economic and environmental aspects are also aimed.
Course Objectives
1. The learning of Industrial chemistry is to help the process of transforming matter into materials that are useful to humanity through chemical processes 2. To learn the pilot planting of medicines like paracetamol 3. To provide new forms of energy and new materials, promoting innovation in all areas of production, thus ensuring a better quality of life 4. To learn the art of manufacturing of polymer materials used for various purposes 5. To learn the rules and regulations to run an industry, pertaining to safety, environmental protection, etc

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End

Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	learn about the various industrial process, need of industrialization and requirement of a chemical industry
C02	learn about the pilot planting and design of its apparatus
C03	study an idea about the various industrial process like distillation, extraction, etc
C04	study the need of quality control and its assurances
C05	study the principle of drug action and metabolism
C06	learn the manufacturing of Ibuprofen and Paracetamol
C07	learn the manufacturing process of various polymers
C08	study about various types of batteries
C09	learn the manufacturing process of fertilizers
C10	study the harmful effects of industries, their management and prevention of pollutions
C11	know about the economic aspects of industry

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Chemistry in Industrial Processes 14 hrs**
1.1	Introduction, Need of industrialization, Requirements for a chemical industry.
1.2	Pilot plant requirements, Design of vessels and bulk production and its automation.
1.3	Industrial catalysis, Common techniques: Distillation, extraction, filtration, crystallization, evaporation
1.4	Quality control and quality assurance
Suggested Reading Specific to the module	
1.1	Vogel's Text Book of Practical Organic Chemistry, by Furniss, Hannaford, Smith and Tatchell, ELBS Longmann
1.2	Introduction to Chromatography- Theory and Practice-V.K. Srivastava and K.K. Srivastava, S.Chand Company Ltd., IV ed., 1991
1.3	Transport Processes and Unit Operations C.J. Geankoplis (4th edition) Prentice Hall of India 1997
1.4	Air pollution control and design hand book P.N. Cheremisioff and R A Yound: Vol-I & II Dekker
2.0	**Life supportive Chemical Industries 14 hrs**
2.1	Introduction: Drug metabolism principles. Drug action, Pharmacokinetics and Biopharmaceutics, Theories of drug dissolution,
2.2	The pharmaceutical industry Manufacture of ibuprofen. Material procurement,

	flow-chart, manufacturing process. Chemistry of synthesis of ibuprofen
2.3	Manufacture of Paracetamol. Action of the drug, chemical reactions involved, raw materials, flow-chart. Quality Control: Sampling plan, In-process quality control tests, Pharmaceutical Analysis
2.4	Fertilizers industries: Manufacture of Urea, Ammonium Sulphate and Ammonium Phosphate. Raw materials, process, chemical reaction and flow chart
Suggested Reading Specific to the module	
2.1	Drug Metabolism Chemical And Ensymatic Aspects, Uetrecht, Informa Healthcare publishers
2.2	Rang and Dale's Pharmacology, Rang H. P., Dale M. M., Ritter J. M., Flower R. J.,.Churchil Livingstone Elsevier
2.3	Active Pharmaceutical Ingredients: Development, Manufacturing, and Regulation (Drugs and the Pharmaceutical Sciences), NUSIM S.H. Taylor & Francis
2.4	Fertilizers Manufacturing Handbook: DAP, Urea - Ammonium Nitrate, Neem Coated Urea, N.P.K. Complex Fertilizers, SSP, Triple Superphosphate, Zinc Sulfate Monohydrate, Magnesium Sulfate with Manufacturing Process, Machinery Equipment Details & Factory Layout), P. K. Chattopadhyay, Niir Project Consultancy Services
3.0	**Life Enhanced Chemical Industries 13 hrs**
3.1	Introduction of polymer industries, manufacture of polyvinyl chloride, Bakelite, Nylon and polyethylene. Raw Materials used.
3.2	Types of moulding techniques, Pipe extrusion, Blow Moulding injection moulding, process development, Applications
3.3	Batteries: Primary and secondary, acid battery, Chemical composition and reactions**.** Advantages and disadvantages of various batteries
3.4	Solid batteries, Carbon Zinc Batteries, lithium ion battery., manufacturing process, advantages, shelf life and applications
Suggested Reading Specific to the module	
3.1	Industrial Polymers, E. Alfredo Campo, Carl Hanser, Verlag GmbH & Co. 2007
3.2	Engineering Polymer Sourcebook, Seymour RB, Mc Graw Hill
3.3	Understanding Batteries, R.M Dell, Paul Connor, D A J Rand, Royal Society of Chemistry
3.4	Modern Battery Engineering, Kai Peter Birke, World Scientific Publishing Co Pte Ltd
4.0	**Industrial Management 13 hrs**
4.1	Harmful effects of industrial pollutants on living and non-living species.
4.2	Air and sound pollutants, Source, prevention and analysis of water pollution.
4.3	Industrial safety parameters, industrial safety and environmental laws,

	environmental protection act, Chemical Process,
4.4	Economics and Entrepreneurship, Quality considerations during packaging operation. Main industries in India
Suggested Reading Specific to the module	
4.1	A Text Book on Environmental Pollution and Control, H S Bhatia, Galgotia Publications.
4.2	Environmental Pollution And Management, Avnish Chauh, Wiley India
4.3	Industrial Safety and Environment, Anupama Prashar, S.K. Kataria & Son publishers
4.4	Industrial Reliability and Safety Engineering, Panchal, Dilbagh, CRC Press

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Basic and clinical pharmacology, Katzung B. G., Masters S. B., Trevor A. J., Tata Mc Graw-Hil
2. Modern Pharmaceutics, Banker, G.S., Rhodes, C.T. 1989. II Edition. Marcel Dekker.l
3. Fundamentals of Medicinal Chemistry, Gareth Thomas, Wiley
4. Industrial Chemistry, Clerk Ranken, Maxwell Press
5 A Short History of Technology: From the Earliest Times to A.D. 1900. Derry, Thomas Kingston; Williams, Trevor I , Dove, New York:
6 Shaping the Industrial Century: The Remarkable Story of the Evolution of the Modern Chemical and Pharmaceutical Industries. Chandler, Alfred D. (2005). Harvard University Press
7 Indian Industry, K.Siddhartha & S.Mukherjee Dr.Qamar Ahsan, Kitab Mahal publishers

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 The Theory and Practice of Industrial Pharmacy,, Lachman, L., Herbert A., 1991 3rd edition, Verghese publishing house.
2. The Fertilizer Industry, Murray-Park, , Google books 2001
3. Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
4. Handbook of Polyethylene, A. J. Peacock, Marcel Dakker Inc,2000
5. PVC Technology, A. S. Athalye and Prakash Trivedi, Multi-Tech Publishing Co, 1994.
6. Engineering Thermoplastics Polycarbonates Polyacetals Cellulose Esters, L. Bottenbruch, Hanser Publishers, 1996

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks

End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Explain the requirements for a chemical industry
2. Why quality control is necessary in industry?
3. Discuss the theories of drug dissolution
4. Discuss the action of Paracetamol
5. Discuss the advantages of injection moulding
6. Discuss the disadvantages of acid batteries
7 Discuss the types of industrial air pollutions
8 Explain the parameters of industrial safety

Semester I	
Elective Course	
Course Code: **MSCHE01DSE03**	Course Name: **Environmental Chemistry**

Course Description
This course focuses on the effects that chemicals have on the air, water and soil and how they impact the environment and human health. It covers the sources, effects, remediation of pollution and instrumental methods in environmental chemical analysis. The course is divided into four modules. The first modules discuss about the internal and incidental pollution, pollution control, environmental law and regulations. The second module deals sources, effects, remediation of air and noise pollution. Third module discuss about sources, effects, remediation of water and radioactive pollution. Fourth module deals with advanced instrumental methods used for environmental chemical analysis.

Course Objectives	
1.	To impart awareness on public health, waste management and pollution
2.	To introduce basic principles of environmental chemistry like environmental processes ecosystems etc
3.	To introduce various environmental policies laws and regulations that are relevant to environmental protection
4.	To understand the interconnections between different sectors of the environment (soil, water, atmosphere) and the effect of human activities on these causing pollution and other impacts
5.	To apply the knowledge on analytical chemistry to environmental processes and samples

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Acquire theoretical knowledge and understanding of fundamental concepts of environmental technology
C02	Understand the impact of human and natural impacts on atmosphere and ecosystem
C03	To understand the type and sources of air, water and soil pollution
C04	To acquire knowledge on air, water and soil pollution control measures
C05	Acquire knowledge about advanced instrumentation facilities used for environmental chemical analysis

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to Environmental Chemistry**	**14 hrs**
1.1	Introduction, important concepts, public health, public awareness, waste treatment	
1.2	Internal and incidental pollution, pollution control, control management	
1.3	Environmental policies, nature and natural process, natural resources, eco systems	
1.4	Social issues and the environmental pollution, environmental law and regulations.	
Suggested Reading Specific to the module		
1.1	Environmental chemistry, A.K. Bhagi and G.R. Chatwal, Himalaya Publishing House	
1.2	Environmental Chemistry, Ian Williams, John Wiley & Sons	
1.3	Environmental chemistry, Peter O'Neill, Blackie Academics	
1.4	Fundamental concepts of Environmental chemistry G.S. Sodhi, Narosa publications	
2.0	**Environmental pollution**	**13 hrs**
2.1	Types of air pollutants: primary and secondary air pollutants, Gaseous, solid and bio pollutants	
2.2	Acid rain and its ecological effects, ozone depletion	
2.3	Greenhouse effect and global warming, thermal pollution	
2.4	Impacts of air pollution on human being, plants, materials, buildings and climate, control measures of air pollution	

2.5	Sources of noise pollution - Indoor and outdoor noise pollution, Impact of noise pollution on plants and animals. control measures of noise pollution
Suggested Reading Specific to the module	
2.1	Environmental Chemistry a global perspective, G.W. vanLoon and S.J. Duffy, Oxford University Press
2.2	Environmental chemistry, Peter O'Neill, Blackie Academics
2.3	Environmental Chemistry, Ian Williams, John Wiley & Sons
2.4	Fundamental concepts of Environmental chemistry G.S. Sodhi, Narosa publications
2.5	S. E. Manahan: Environmental Chemistry, Lewis Publishers, Inc., 1994
3.0	**Water and Soil Pollutions 13 hrs**
3.1	Water pollution: soluble metals, soaps and detergents, insecticides and pesticides, control of water pollution
3.2	Sources of soil pollution, Soil pollution: ground water, heavy metal poisoning
3.3	Industrial pollution, agriculture pollution, radiation and radioactive pollution
3.4	Marine and coastal pollution, Sources of marine pollution, control measures, pollution status of coastal and ocean waters
Suggested Reading Specific to the module	
3.1	S. E. Manahan: Environmental Chemistry, Lewis Publishers, Inc., 1994
3.2	Environmental chemistry, Peter O'Neill, Blackie Academics
3.3	C. Baird, Environmental Chemistry, W. H. Freeman and Company, 1998.
3.4	Environmental chemistry, A.K. Bhagi and G.R. Chatwal, Himalaya Publishing House
4.0	**Environmental chemical analysis 14 hrs**
4.1	Analytical methods for the detection and monitoring of indoor pollution, instrumental methods used for the analysis of atmospheric aerosols, sound pollution and radioactive pollution
4.2	Analysis of drinking water for total oxygen content, turbidity, and organics. ion selective electrodes for in-situ measurements of different ions
4.3	Chromatography technique is used for the detection of organic compounds – HPLC and GC
4.4	Instrumental methods in environmental chemical analysis - Chemiluminescence Spectroscopy, FT-IR spectroscopy, Atomic absorption spectroscopy
4.5	Neutron activation analysis, Raman spectroscopy, anodic stripping voltammetry,
Suggested Reading Specific to the module	
4.1	Lain. Marr and Malcolm S Cresser, Environmental Chemical Analysis, International textbook company (pub), New York, 1983.
4.2	Daniel C. Harris, Quantitative Chemical Analysis, 4th Ed.., W.H. Free man and Company, New York, 1995
4.3	Daniel C. Harris, Quantitative Chemical Analysis, 4th Ed.., W.H. Free man and

	Company, New York, 1995
4.4	D.A. Skoog and J.J. Leary, Principles of Instrumental Analysis, 4th ed., Saunders college Publishing, Fort Worth, 1992
4.5	Vanloon,Wary, Environmental Chemistry, Oxford University, New York, 2015

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Environmental Chemistry a global perspective, G.W. vanLoon and S.J. Duffy, Oxford University Press.
2 Environmental chemistry, A.K. Bhagi and G.R. Chatwal, Himalaya Publishing House
3 Environmental Chemistry, Ian Williams, John Wiley & Sons
4 Environmental chemistry, Peter O'Neill, Blackie Academics
5 Fundamental concepts of Environmental chemistry G.S. Sodhi, Narosa publications
6 C. Baird, Environmental Chemistry, W. H. Freeman and Company, 1998.
7 D. W. Hawker, D. W. Conell, M. Warne, P. D. Vowles: Basic Concepts of Environmental Chemistry, Lewis Publishers, Inc..1997.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 R.P. Schwarzenbach, P.M. Gschwend, D.M. Imboden: Environmental Organic Chemistry, J. Wiley and Sons, Inc. 1998.
2 A. G. Howard: Aquatic Environmental Chemistry, Oxford Science Publ., 1998.
3 S. E. Manahan: Environmental Chemistry, Lewis Publishers, Inc., 1994

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1 Explain the various types of spectroscopic techniques used for environmental analysis
2 Explain the chemistry of chlorofluorocarbons in depleting the ozone layer.
3 Discuss the major objectives of environmental pollution monitoring.
4 Discuss your views on the global perspective of Environmental pollution.
5 Write a short note on adverse effects of acid rain.

Semester II
Core Course

Course Code:	Course Name:
MSCHE02DSC05	**Reactive Organic Chemistry**

Course Description
The course gives an overall idea about the different types of organic reactions and their mechanisms. Organic named reaction, their characteristics, stereo chemical aspects and applications are included. The mechanisms of important organic rearrangement reactions are described. The coupling reactions and formation, reactions and applications of heterocyclic compounds are added.

Course Objectives	
1.	To study of basic principles of organic chemistry,
2.	To help the students to gain experience to predict the functional group transformations
3.	To learn the simple reaction mechanisms
4.	To understand the synthesis of organic molecules by multi-step synthesis strategies.
5.	To help the students to understand the reaction mechanism subjects in later stages of their study

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	learn the basic principles of organic reactions and its effects on various circumstances and reaction conditions.
C02	understand the chemistry of heterocycles, their preparation methods and basic reactions
C03	illustrate the reaction pathways of Michael, Stobbe, Knoevenagal, Darzen, Dakin, Mannich, Heck reactions
C04	interpret Negishi, Sonogashira, Suzuki and Ullmann coupling reactions
C05	learn the mechanisms, driving force and applications of rearrangement reactions of type Bamberger, Beckmann, Benzilic acid, Classien, Curtus, Demjanov, Di-pi methane, Dienone-phenol, Favorskii, Fischer – Hepp, Fries, Hoffmann, Lossen, Schmidt reactions
C06	Illustrate the synthesis, reactions and applications of five and six membed heterocyclic compounds
C07	develop an idea of photochemical reactions and its applications

C08	describe the basic pericyclic reactions with types and applications

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Reaction Mechanisms 18 hrs**
1.1	Mechanisms of nucleophilic aliphatic substitution, electrophilic aliphatic and aromatic substitution
1.2	Mechanisms of organic reactions: Michael, Stobbe, Darzen, Dakin, Mannich and Cannizzarro reactions.
1.3	Condensation reactions: Mechanisms and applications of Aldol, Benzoin, Knoevenagel condensation and Claisen condensations
1.4	Coupling reactions: Mechanisms and applications of Negishi, Sonogashira, Heck, Suzuki and Ullmann coupling reactions
1.5	Oxidation and Reduction reactions: Mechanisms and applications Baeyer-Williger and Oppenauer oxidations, Birch reduction
Suggested Reading Specific to the module	
1.1	Advanced Organic Chemistry, Part B: Reaction and Synthesis, F.A. Carey and R. S. Sundberg, 5th Edition, Springer
1.2	March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, 7th Edn, Wiley
1.3	Principles of organic Synthesis, R.O.C Norman, J.M.C. Frsnz, ELBS
1.4	Principles Of Organic Chemistry, Norris James F, MJP Publishers
1.5	Name Reactions: A Collection of Detailed Mechanisms and Synthetic Applications, Jie Jack Li, Fifth Edition, Springer
2.0	**Rearrangement reactions 18 hrs**
2.1	Amine formation reactions: Mechanisms and application of Hoffmann, Lossen, Schmidt and Curtius rearrangements.
2.2	Reactions involving migration of groups: Mechanisms and application of Dienone-phenol, Fries, Fischer – Hepp and Classien rearrangements
2.3	Reactions involving insertions: Mechanisms and application of Beckmann, Demjanov, Benzilic acid, Favorskii and Di-pi methane rearrangements
2.4	Reactions involving formation of new groups: Mechanisms and application of Bamberger, Wagner- Meerwein and von Richer rearrangements
2.5	Reactions involving Nitrogen groups: Mechanisms and application of rearrangement reactions: Sommelet- Hauser and Stevens rearrangements
Suggested Reading Specific to the module	
2.1	Chemistry of the Carbonyl Group - A Step-by-Step Approach to Understanding Organic Reaction Mechanisms, Timothy K. Dickens, Stuart Warren, Wiley
2.2	Organic Chemistry, Michael S. Leonard, 2016
2.3	Organic Reactions and their Mechanisms, A. Mohamed Sikkander Noor Shawal

	Nasri, Viva Books
2.4	Textbook of organic name reactions, Kashaw S.K. Atithi books
2.5	Reaction mechanisms in organic synthesis, Parashar, John Wiley and Sons
3.0	**Heterocyclic chemistry 18 hrs**
3.1	Introduction to heterocyclic compounds, Nomenclature of Heterocyclic compounds, Biologically important heterocycles, three and four membered heterocycles
3.2	Five membered heterocyclic compounds: Synthesis and reactions of pyrrole furan and thiophene,
3.3	Six membered heterocyclic compounds: Synthesis and reactions of pyridine, pyran and thiopyran
3.4	Fused rings: Synthesis and reactions of indole, quinoline, isoquinoline and benzofuran,
3.5	Heterocyclic compounds with more than one hetero atoms: chemistry of pyramidines and purines, synthesis of imidazole, pyrazole and oxazole
Suggested Reading Specific to the module	
3.1	Heterocyclic chemistry, Thomas L. Gilchrist, Pearson Education
3.2	Heterocyclic chemistry, J.A. Jouls and K. Mills, fifth edn, Wiley
3.3	Heterocyclic Chemistry, Raj K. Bansal, New Age International, 2020
3.4	Chemistry of Heterocyclic Compounds, Rakesh Kumar Parashar, and Beena Negi, Ane Books Pvt Ltd
3.5	Heterocyclic Chemistry at a Glance, John A. Joule, Keith Mills, John Wiley & Sons, Ltd, 2013
4.0	**Photochemistry and Pericyclic reactions 18 hrs**
4.1	Organic photochemistry: photochemical reactions, photo addition, photo oxidation, photo rearrangement, photo dissociation, photo cyclization
4.2	Photochemistry of carbonyl compounds, alkenes and dienes, Photochemistry of aromatic compounds Barton and Hoffman-Lofferty reactions, applications of photochemistry
4.3	Pericyclic reactions: classification, cycloadditions, electrocyclic, sigmatropic, chelotropic and group transfer reactions,
4.4	Claisen, Cope and Diels-Alder reactions. Their stereochemical aspects, dipolar cycloadditions and their utility in organic synthesis.
4.5	The ene- reactions, Cheletropic reaction, Dyotropic reaction, applications of pericyclic reactions
Suggested Reading Specific to the module	
4.1	Organic Photochemistry, J.M Coxon, B Halton, Cambridge University Press
4.2	Photochemistry of Organic Compounds: From Concepts to Practice. P. Klán, J. Wirz Wiley, Chichester, 2009
4.3	Textbook of Pericyclic Reactions Concept and Application, K.C Majumdar, P.

	Biswas, Medtech publishers
4.4	Frontier orbital and symmetry controlled pericyclic reactions, Ratan Kumar Kar, Books & Allied Ltd, 2009
4.5	Pericyclic Reactions, G. Gill, Chapman and Hall

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 IUPAC, Compendium of Chemical Terminology, 2nd ed. (the "Gold Book") (1997). Online corrected version: (2006) Hantzsch–Widman name". doi:10.1351/goldbook. H02737

3 An Introduction to the Chemistry of Heterocyclic Compounds, Acheson, R. M. 3rd Ed, Wiley India Pvt Ltd, 2008

4 Alfred Hassner, C. Stumer. Organic syntheses based on name reactions. Elsevier, 2002

5 The Art of Writing Reasonable Organic Reaction Mechanisms, Robert B. Grossmann, 3rd ed. 2019, Springer

6 Determination of Organic Reaction Mechanisms, Barry K. Carpenter, Wiley Inter-science

7 Principles and Applications of Photochemistry, Brian Wardle, Wiley, 2010

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Hantzsch-Widman nomenclature, IUPAC (link)

2 Arman Raza (2018). "Organic Name Reactions. A contribution to the terminology of organic chemistry, biochemistry, and theoretical organic chemistry. Helmut Krauch and Werner Kunz. Translated from the second revised German edition by John M. Harkin. Wiley, New York, 1964

3 Reactions Rearrangements And Reagents, S N Sanyal, Bharati Bhawan Publishers & Distributors

4 Organic Name Reactions And Unified Approach, Goutam Brahmachari, Narosa publishers

5 Organic Chemistry: Theory, Reactivity and Mechanisms in Modern Synthesis, Pierre Vogel and Kendall N. Houk, Wiley -VCH

6 Microwave Assisted Organic Synthesis, J.P. Tierney and P. Lidstrom, B Lack-Well publishers

7 Photochemistry And Pericyclic Reactions, Jagdamba Singh, Jaya Singh, New age international

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%

Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Compare the mechanisms of S_N1 and S_N2 reactions
2. 'Formaldehyde gives Cannizzaro's reaction while acetaldehyde does not' Why?
3. Discuss the mechanism and stereochemistry of Beckmann rearrangement
4. Discuss the mechanism of von Richer rearrangement
5. Discuss the mechanism of Pall – Knor synthesis of pyrrole
6. Explain the mechanism of Fischer indole synthesis

7 Discuss the applications of photochemical reactions

8 Discuss the various types of pericyclic reactions

Semester II	
Core Course	
Course Code: **MSCHE02DSC06**	Course Name: **Analytical Chemistry**

Course Description
The primary objective of this course is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results. To know about the latest characterisation techniques and instrumentation details of sophisticated instruments

Course Objectives	
1.	To develop an understanding of the range and uses of analytical methods in chemistry.
2.	To establish an appreciation of the role of chemistry in quantitative analysis.
3.	To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks.
4.	To provide an understanding of chemical methods employed for elemental and compound analysis.
5.	To provide experience in modern scientific methods and instruments employed in analytical chemistry and material science.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	The student learns the skill to prepare standard solution, samples and analysis of the samples through using accurate methods. The course make the student to learn how to prepare solutions quantitatively and analysis the analyte with high accuracy.
C02	Apply the knowledge of chromatography to Separates the constituents from a complex mixture.
C03	Students will learn physical, chemical and biological characterization methods
C04	Students will learn in detail about X-ray diffractometry, Scanning probe microscopy and scanning tunnelling microscopy, Optical microscopy– SEM, TEM, AFM, UV-Vis-NIR spectrometry and FTIR

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to analytical methods**	**18 hrs**
1.1	Introduction to analytical and instrumental methods, Classification of analytical techniques, nature and origin of errors, accuracy and precision, statistical evaluation of data, tests of significance, Students 't' test, 'F' test, significant figures and computation rules.	
1.2	Precipitation phenomena, organic precipitants in inorganic analysis,	
1.3	Extraction of metal ions, nature and types of extractants and its applications, chelometric titration,	
1.4	Masking and de masking techniques, industrial applications of masking. Separation techniques:	
1.5	Solvent extraction, batch and continuous extractions, extraction of metal ions, nature and types of extractants and its applications.	
	Suggested Reading Specific to the module	
1.1	Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole	
1.2	Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press	
1.3	Modern analytical chemistry, Harvey, Mc Graw Hill	
1.4	Organic Analytical Chemistry, Jagmohan, Narosa Publications	
2.0	**Chromatography and Electroanalytical methods**	**18hrs**
2.1	Introduction to chromatography, classification of chromatographic methods, theory, techniques and applications of Paper chromatography, Column chromatography	
2.2	Thin layer chromatography (TLC), high performance liquid chromatography (HPLC), Gas chromatography (GC).	

2.3	Radio analytical methods: Introduction, principle and application of neutron activation analysis (NAA), isotope dilution analysis and radiometric titrations. Electro analytical methods:
2.4	Principles and applications of Voltammetry, Cyclic voltammetry (CV), Polarography, Stripping voltammetry, Conductometry, Amperometry, Potentiometry and Electrogravimetry.
Suggested Reading Specific to the module	
2.1	Principles and practice of Analytical Chemistry, F.W. Fifield and D. Kealeg, Blackwell publications
2.2	Principles of Instrumental Analysis by Douglas A. Skoog; F. James Holler; Stanley R. Crouch
2.3	Fundamentals of Analytical Chemistry by Douglas A. Skoog; Donald M. West; F. James Holler; Stanley R. Crouch
2.4	Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
2.5	Analytical Chromatography by G.R. Chatwal
3.0	**Spectroscopy and microscopy methods of analysis 18 hrs**
3.1	Introduction to instrumentation, method of samplings, data analysis and applications to chemistry of the followings, Attenuated Total Reflection Spectroscopy
3.2	Electronic Spectroscopy for Chemical Analysis (X-ray Photo Electron Spectroscopy),UV-Photo Electron Spectroscopy.
3.3	Ion Scattering Spectroscopy, Secondary Ion Mass Spectroscopy, Auger Electron Spectroscopy
3.4	Principles, general instrumentation and applications of Scanning Electron Microscopy, Scanning Tunneling Electron Microscopy, Atomic Absorption Spectroscopy and Instrumentations of NMR, IR, UV-Visible and Mass spectrometry
Suggested Reading Specific to the module	
3.1	Principles and practice of Analytical Chemistry, F.W. Fifield and D. Kealeg, Blackwell publications
3.2	Principles of Instrumental Analysis by Douglas A. Skoog; F. James Holler; Stanley R. Crouch
3.3	Fundamentals of Analytical Chemistry by Douglas A. Skoog; Donald M. West; F. James Holler; Stanley R. Crouch
3.4	Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
4.0	**Instrumental methods of analysis 18 hrs**
4.1	Principles, instrumentation and applications of thermogravimetry (TGA-DTA), Differential Scanning Calorimetry, Dynamic Mechanical Analyzer

4.2	Dynamic Chemical Analyzer, Direct injection enthalpymetry and thermometric titrimetry,
4.3	Principles, instrumentation and applications of Fluorimetry, Phosphorimetry, Flame photometry, Nephelometry and Turbidimetry,
4.4	X-ray crystallography.
Suggested Reading Specific to the module	
4.1	Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole
4.2	Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
4.3	Modern analytical chemistry, Harvey, Mc Graw Hill
4.4	Principles and practice of Analytical Chemistry, F.W. Fifield and D. Kealeg, Blackwell publications

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Principles of quantitative chemical analysis, de Levine, Mc Graw Hill
2. Vogel's Qualiitative Inorganic Analysis, Pearson Education
3. Vogel's Quantitative chemical analysis, Pearson Education
4. Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole
5. Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
6. Modern analytical chemistry, Harvey, Mc Graw Hill
7. Principles and practice of Analytical Chemistry, F.W. Fifield and D. Kealeg, Blackwell publications

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Chromatography: Concepts and Contrasts by James M. Miller
2. R.L. Pecsok, L.D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
3. G.D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.
4. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
5. J.H. Kennedy, Analytical Chemistry: Principles, 2nd Edn (1990), Saunders Holt, London.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks

End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Explain the principle of HPLC?
2. Define the terms elution and eluent?
3. How is paper partition chromatography different from paper adsorption chromatography?
4. Explain the significance of Rf value in chromatographic separation?
5. What is NAA? Give any one use of this technique.

Semester II	
Core Course	
Course Code: **MSCHE02DSC07**	Course Name: **Experimental Organic Chemistry**

Course Description
The course is aimed the students should have an experience with the organic laboratory experiments. Separation of organic binary mixtures using acidic and basic reagents. Separated components are analyzed for identification of its components. Groups such as aldehyde, ketone, acid, amine, halogens, amide, etc are to be identified. Double stage organic preparations and synthesis of organic named reactions are also included. Estimation of phenol, aniline and glucose. A hands on experiment of chromatographic technique is also included.

Course Objectives
1. To learn the basic organic separation analysis of acids, bases, phonolic and neutral compounds from one another.
2. To study the identification of organic groups through chemicl reactions
3. To learn the method of double stage synthesis of organic reactions
4. To experience the synthesis of organic named reactions
5. To be able to do the organic estimations
6. To study the basics of chromatography and allied techniques of purifications
7. To learn the extraction techniques of natural products

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
0	4	4	0	288	288	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	separate the organic mixtures into single components
C02	estimate the percentage content of phenol, aniline and glucose
C03	identify organic compound using group identification tests
C04	learn the preparation of solid derivatives
C05	prepare new compounds applying many reactions and identify them using physical parameters
C06	Learn the extraction techniques of natural products
C07	handle and carryout many laboratory identification methods such as chromatography and distillation, etc

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Analysis of organic binary mixtures 90 hrs**
1.1	Separation of organic binary mixtures of acidic, basic, phenolic and neutral groups.
1.2	Analysis of individual components of the mixture. One component has one group and the other should have two groups.
1.3	Preparation of derivatives for individual components. Recrystallization of the derivatives,
1.4	Determination of physical constants such as melting/ boiling points, of the individual components Total of 8 mixtures
Suggested Reading Specific to the module	
1.1	Vogel's Textbook of Practical Organic Chemistry. Furniss , Brian S, Hannaford and Antony, 5th Edition, Pearson India
1.2	Advanced Practical Organic Chemistry, J. Leonard, B, Lygo and G. Procter, Nelson Thornes
1.3	Lab experiments in organic chemistry, A. Sethi, New Age international
1.4	Organic synthesis special techniques, V.K. Ahluwalia, Renu Aggarwal, Alpha Science
2.0	**Physical Organic Experiments 20 hrs**
2.1	Estimation of phenol
2.2	Estimation of aniline
2.3	Estimation of glucose,
2.4	Estimation of lactose in milk,
Suggested Reading Specific to the module	
2.1	Practical Organic Chemistry, F.G. Mann and B C Saunders, Longman
2.2	Systematic identification of organic compounds, Shriner, Hermann, Morrill,

	Curtin and Fuson, John Wiley
2.3	Practical Organic Chemistry Volume-I, Sharda Pasricha and Ankita Chaudhary, 2022, Wiley India
2.4	Laboratory Manual in Organic Chemistry–Dey & Sitaraman, (Allied publishers
3.0	**Preparative organic chemistry 80 hrs**
3.1	Double stage preparation and identification of organic compounds. Electrophilic substitution reactions–Preparations of p-bromoaniline/ p-nitroaniline/ 2,4,6- tribromophenol
3.2	Acetylations–Preparations of -D-glucose penta-acetate/ 2-naphthyl acetate. Condensation reactions–Condensations involving diethyl malonate and ethyl acetoacetate. Claisen-Schmidt, Sandmayer's, Aldol and Perkin condensation reactions
3.3	Reactions with ring formation– Preparations of 1,2,3,4–tetrahydrocarbazole/ 1-phenyl-3-methyl-5-pyrazolone/ 7– hydroxy-4-methyl-coumarin
3.4	Diazotization reactions–Preparations of iodo, chloro and azo compounds. Dehydration reactions–Preparations of cyclohexene and succinic anhydride (Any 4)
Suggested Reading Specific to the module	
3.1	Advanced Practical Organic Chemistry, John Leonard , Barry Lygo, Garry Procter, T&F India
3.2	Organic Chemistry: Lab Manual, N.S. Gnanpragasam,, G. Ramamurthy, Viswanathan, S., Printers & Publisher
3.3	Laboratory Techniques In Organic Chemistry, V K Ahluwalia, Pooja Bhagat, Renu Aggarwal, I K International Publishing House Pvt Ltd
3.4	Experiments in Organic Chemistry, R. Ramanujam, G. Sharma, Pacific Books International
4.0	**Organic Separation Techniques 26 hrs**
4.1	Thin layer chromatography:,:
4.2	Monitoring of a chemical reaction
4.3	Soxhlet Extraction of natural plant leaves
4.4	Determination of saponification/ iodine value of an oil
Suggested Reading Specific to the module	
4.1	Compendious Practical Organic Chemistry : Preparations Isolation And Chromatography, Basavarajaiah S M., Notion Press Media Pvt Ltd
4.2	Laboratory Manual in Organic Chemistry–R. K. Bansal, New Age, New Delhi
4.3	Systematic Laboratory Experiments In Organic Chemistry, Arun Sethi, New Age International
4.4	Experimental Organic Chemistry, Sonia Ratnani and Shriniwas Gurjar, Prentice-Hall

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Organic Chemistry Laboratory Course Book, Pradip V. Tekade, Selective & Scientific Books
2 Laboratory Techniques in Organic Chemistry, Christina Noring Hammond, Jerry R Mohrig, Gretchen Hofmeister, David G. Alberg, Gretchen E. Hofmeister, Publisher: W.H. Freeman & Co Ltd
3 Organic Lab Manual , Shailendra Kumar Sinha, Atlantic

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Structural determination of organic compounds, E. Pretsch, P. Buhlmann and C. Affolter, Springer
2. Experimental Organic Chemistry–Vol. I & II–P. R. Singh et al (TMH New Delhi) 1981
3. Experimental Organic Chemistry- H.D. Durst & G.E. Goke(McGraw-Hill) 1980
4 A Microscale Approach to Organic Laboratory Techniques, Donald L Pavia, G.M Lampman, George S. Kriz, Ronald G. Engel, Cengage Learning, Inc
5 Understanding The Principles Of Organic Chemistry: A Laboratory Course, Arlyn Myers, Steven Pedersen, Books/Cole

Teaching Learning Strategies

- Practical, Viva Voce

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Discuss the methods of identification of bromine and chlorine in organic analysis
2. Explain Lassaign test for identification of sulphur
3. Discuss the order of reagents used for separation of organic compounds
4. Explain the procedure for the Beckmann rearrangement
5. Discuss the various precautions to be taken for bromination experiment
6. Illustrate the procedure for the nitration of acetanilide.
7 Discuss the methods used for the monitoring of a chemical reaction
8 Describe the various types of chromatographic techniques

Semester II	
Elective Course	
Course Code: **MSCHE02DSE04**	Course Name: **Coordination Chemistry - (Part II) & Structural inorganic chemistry**

Course Description
Upon completion of this course, the students will be able to understand and apply the various aspects of spectroscopy to elucidate the structure of transition metal complexes. student should be capable of interpreting the electronic spectra of metal complexes for further applications. By studying the reactions of metal complexes, the student can understand the applications of coordination compounds in qualitative as well as quantitative chemical analysis.

Course Objectives	
1.	The course predicts and explains patterns of the various theories of spectroscopy applicable to coordination compounds, thereby understanding and applying concepts in various aspects of coordination chemistry
2.	To understand the magnetic and spectral properties of transition metal complexes.
3.	The objective of the course is also intended to realize the different types of reactions in transition metal complexes.
4.	Introduce the leaners the different types of cage, ring and cluster compounds.
5.	Understand the chemistry of ring, cage and cluster compounds.Their preparation, physical and chemical properties, diverse stoichiometries and nuclearities, stability etc.
6.	Wade's electron counting rules to predict trends in the stability and structures of many metal clusters.
7.	Metal carbonyl cluster compounds to evaluate as catalysts for a wide range of reactions

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	Apply STYX number in rationalizing the structure of main group clusters
C02	Predict the magnetism in coordination complexes.
C03	Interpret spectral characteristics of coordination complexes.
C04	Constuct orgel diagrams and recognize the electronic transition in the spectra of any coordination complexes.
C05	Derive the term symbol for any electronic configuration.
C06	Assess the stability of coordination complexes by the use of formation constants and to calculate thermodynamic parameters from them.

C07	Compare the products formed after electron transfer reaction between two coordination complexes.
C08	Differentiate basic composition, structures and properties of compounds containing phosphorous, nitrogen and boron.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Coordination Chemistry-I**	**14 hrs**
1.1	Optical activity of coordination compounds, ORD and CD, Cotton effect and applications. IR spectra of simple inorganic compounds and metal complexes, changes in ligand vibrations on coordination, metal ligand vibrations.	
1.2	NMR spectroscopy for structural investigation of diamagnetic metal complexes from chemical shift and spin-spin coupling.	
1.3	EPR spectra of metal complexes – hyperfine splitting, g-values, zero field splitting and Kramer's degeneracy. Applications to copper (II) complexes. Mossbauer spectra – application to iron complexes,	
1.4	Mossbauer effect, hyperfine interactions, isomer shift, electric quadrupole and magnetic hyperfine interactions. Importance of molar conductance measurements in coordination chemistry.	
	Suggested Reading Specific to the module	
1.1	Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel, J. Alexander	
1.2	Inorganic Chemistry, Shriver & Atkins, Oxford.	
1.3	Coordination Chemistry, S. F. A. Kettle, Longman.	
1.4	Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson Education	
2.0	**Coordination Chemistry-II**	**14 hrs**
2.1	Magnetic susceptibility measurements, Gouy method, diamagnetic corrections, spin only value, orbital contribution, spin orbit coupling, ferro and antiferro magnetic coupling	
2.2	Spin crossover systems, application of magnetic moment measurements for the structural determinations of transition metal complexes.	
2.3	Term symbol for d^n ions, spectroscopic ground states, selection rules for d-d transitions, Orgel diagrams for transition metal complexes (d^1 to d^9 configuration)	
2.4	Tanabe-Sugano diagrams, interpretation of spectra of spin paired and spin free octahedral, distorted octahedral, tetrahedral and square planar complexes, charge transfer transitions. Electronic spectra of f-block metal complexes.	
	Suggested Reading Specific to the module	
2.1	Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson	

	Education.
2.2	Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel, J. Alexander
2.3	Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson Education.
2.4	Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson Education.
3.0	**Coordination Chemistry-III 13 hrs**
3.1	Metal ligand equilibria in solutions, Stability constants, Chelate effect, Irwing-William order of stability, Binary formation constants, Energy profile of a reaction
3.2	Inert and labile metal complexes, Ligand substitution reactions in octahedral metal complexes-A, D and I mechanisms. Acid hydrolysis, base hydrolysis, isomerisation and anation reactions.
3.3	Substitution reactions in square planar complexes, *trans* effect - its theory and applications, *cis*-effect. Redox reactions
3.4	Inner sphere and outer sphere reactions, Complimentary and non-complimentary reactions. Reactions of coordinated ligands.
Suggested Reading Specific to the module	
3.1	Inorganic Chemistry, Shriver & Atkins, Oxford.
3.2	Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel, J. Alexander
3.3	Coordination Chemistry, F Basolo R Johnson, Benjamin Inc.
3.4	Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson Education
4.0	**Structural Inorganic Chemistry 13 hrs**
4.1	Sulphur-nitrogen compounds: tetrasulphurtetranitride, disulphurdinitride and polythiazyl. Sulphur-phosphorus compounds: Molecular sulphides. Phosphorus-nitrogen compounds: Phosphazines, cyclo and linear phosphazines, other P-N compounds.
4.2	Boron hydrides: Synthesis, reactivity, structure and bonding, Topological approach to boron hydride structure, *Styx* numbers, Icosahedral frame work, *Closo, Nido* and *Arachno* structures, Wades rules, Carboranes, Metalloboranes, Metallocarboranes, Boron-Nitrogen compounds, Boron nitride, Borazines.
4.3	Metal clusters: Factors favouring the formation of metal-metal bonds. Metal carbonyl clusters, Anionic and hydrido clusters
4.4	LNCC and HNCC, Isoelectronic and isolobal relationships, Hetero atoms in metal clusters, Electron counting rules for HNCC, Capping rule.
Suggested Reading Specific to the module	
4.1	Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson

	Education
4.2	Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel, J. Alexander,
4.3	Inorganic Chemistry, Shriver & Atkins, Oxford
4.4	Concise Inorganic Chemistry J.D. Lee, Blackwell

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson, , Wiley.
2. Inorganic Chemistry- Principles of structure and reactivity, J E Huhee, Pearson Education
3. Inorganic Chemistry, A.G. Sharpe, Pearson Education
4. Inorganic Chemistry, Shriver & Atkins, Oxford
5. Chemistry of Coordination compounds, J C Bailar, Reinhold.
6. Concepts and Models of Inorganic Chemistry, B. Douglas, D. Mc Daniel, J. Alexander,
7. Concise Inorganic Chemistry J.D. Lee, Blackwell
8. Coordination Chemistry, D Banergea, Tata McGraw Hill.
9. Coordination Chemistry, F Basolo R Johnson, Benjamin Inc.
10. Coordination Chemistry, S. F. A. Kettle, Longman.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Electronic Absorption Spectroscopy and Related Techniques, D N Sathynarayana, Universities Press.
2. Elements of magneto Chemistry, R L Dutta and A Syamal, S Chand & Company Ltd.
3. Modern coordination Chemistry , E. Lewis and R.G Wilkins (Eds.), Inter-science

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Construct and describe Tanabe-Sugano diagrams
2. Describe electron counting rules for HNCC with suitable example.
3. Discuss about the structure and preparation of boron-nitrogen compounds
4. Illustrate Kramer's degeneracy with an example.
5. Differentiate between Carboranes, Metalloboranes

Semester II	
Elective Course	
Course Code: **MSCHE02DSE05**	Course Name: **Group Theory and Spectroscopy**

Course Description
Symmetry plays an important role in molecular spectroscopy, in quantum mechanics as well as in the determination of structure of molecules and understanding of stereochemistry. This course will help to recognize symmetry of molecules and determining spectroscopic selection rules based on molecular symmetry. The course will also explore the role of symmetry in determining molecular properties such as optical activity and dipole moment. The course is divided into four modules. The first modules discuss about different symmetry elements and symmetry operations in molecules, determination of point groups of molecules and matrix representation of symmetry operations. The second module deals with the Great Orthogonality Theorem and applications of group theory. Third module discuss about the theoretical background of rotational and vibrational spectroscopy. Fourth module deals with the electronic and NMR spectroscopy techniques.

Course Objectives	
1.	To develop an understanding of the principles of molecular symmetry.
2.	To provide advanced knowledge on fundamental aspects of classifying molecules based on various symmetry elements, point groups and relate their vibrational spectroscopic features.
3.	To introduce some useful applications of group theory in chemistry.
4.	To impart qualitative and quantitative knowledge about principles and applications of different spectroscopic techniques

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Predict the symmetry of a molecule or an object.
C02	Identify point groups and construct character table of molecules
C03	Predict hybridization and spectral properties based on symmetry of molecules
C04	Acquire qualitative and quantitative knowledge of the fundamental concepts of various spectroscopic methods
C05	Distinguish between various spectroscopic transitions

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Molecular symmetry**	**14 hours**
1.1	Molecular symmetry, groups and matrices: Symmetry elements and symmetry operations in molecules, point groups and their determinations, Schoenflies and their symbols	
1.2	Mathematical group, sub group, Abelian and cyclic group, group multiplication tables, classes in a group	
1.3	Similarity transformations of matrices, addition and multiplication of matrices, inverse of a matrix, character of a matrix,	
1.4	Block diagonalization, matrix form of symmetry operations, isomorphism Matrix representation of symmetry operations, representation of groups	
1.5	Construction of representation using vectors and atomic orbital as basis, representation generated by cartesian coordinates positioned on the atoms of a molecule (H_2O as example)	
Suggested Reading Specific to the module		
1.1	A Simple Approach to Group Theory in Chemistry, S Swarnalakshmi, Universities Press	
1.2	Chemical Applications of Group Theory, F A Cotton, Wiley Eastern	
1.3	Symmetry in Chemistry, Jaffe and Archin	
1.4	Group Theory and Its Applications In Chemistry, Salahuddin Kunju, G Krishnan, PHI Learning Pvt. Ltd	
1.5	A Simple Approach to Group Theory in Chemistry, S Swarnalakshmi, Universities Press	
2.0	**Group Theory**	**13 hrs**
2.1	Reducible and irreducible representations, construction of irreducible representation by reduction, Great Orthogonality Theorem (GOT) (without proof).	
2.2	Properties of irreducible representations, construction of irreducible representation using GOT, construction of character tables (C_{2V}, C_{3V}, C_{4V})	
2.3	Applications of group theory: Applications to molecular vibrations, symmetry aspects of molecular vibrations, vibrations of polyatomic molecules	
2.4	Selection rules for vibrational absorption, complementary character of IR and Raman spectra, determination of the number of active IR and Raman lines	
2.5	Construction of hybrid orbital (BF_3, CH_4, PCl_5 as examples), transformation properties of atomic orbital.	
Suggested Reading Specific to the module		
2.1	Group Theory and Its Applications In Chemistry, Salahuddin Kunju, G Krishnan, PHI Learning Pvt. Ltd	

2.2	A Simple Approach to Group Theory in Chemistry, S Swarnalakshmi, Universities Press
2.3	Molecular Symmetry and Group Theory, Robert L. Carter, Wiley.
2.4	Group Theory and Symmetry in Chemistry, L H Hall, Mcgraw Hill.
2.5	Group Theory and Its Applications In Chemistry, Salahuddin Kunju, G Krishnan, PHI Learning Pvt. Ltd
3.0	**Spectroscopy-I 14 hours**
3.1	Electromagnetic radiation: Regions of the spectrum, interaction of electromagnetic radiation with matter and its effect on the energy of molecules, selection rules, transition moment integral
3.2	Microwave spectroscopy, rotational spectra of diatomic and polyatomic molecules, rigid and non-rigid rotator models, determination of bond lengths, isotope effect on rotation spectra.
3.3	Vibrational energies of diatomic molecules: Interaction of radiation with vibrating molecules, determination of force constant, anharmonicity of molecular vibrations, fundamental, overtones and hot bands
3.4	Degrees of freedom of polyatomic molecules and nature of molecular vibrations (CO_2 and H_2O as examples). Vibration-rotation spectra of diatomic and polyatomic molecules.
3.5	Theory of Raman spectra (classical and quantum mechanical theory): Rotational and vibrational Raman spectroscopy, mutual exclusion principle
3.6	Applications of Raman and IR spectroscopy in elucidation of molecular structure (H_2O, N_2O and CO_2 molecules as examples
Suggested Reading Specific to the module	
3.1	Fundamentals of Molecular Spectroscopy, P.S. Sindhu
3.2	Molecular Spectroscopy, Barrow, McGraw Hill.
3.3	Molecular Structure and Spectroscopy, G Aruldas, Prentice Hall.
3.4	Fundamentals of Molecular Spectroscopy, Banwell and McCash, Tata McGraw Hill
3.5	Atomic and Molecular Spectroscopy, Gupta
3.6	Vibrational Spectroscopy, S. Narayana
4.0	**Spectroscopy-II 13 hours**
4.1	Electronic spectra of diatomic molecules: Vibrational coarse structure and rotational fine structure of electronic spectrum, Franck-Condon principle, types of electronic transitions, Fortrat diagram, dissociation and predissociation
4.2	Nuclear Magnetic Resonance Spectroscopy: Magnetic properties of nuclei, theory and measurement techniques, population of energy levels, solvents used
4.3	Chemical shift and its measurement, factors affecting chemical shift, relaxation methods. Integration of NMR signals, spin-spin coupling, coupling constant 'j' and factors affecting it

4.4	Shielding and de-shielding, chemical shift assignment of major functional groups (ABX, AMX, ABC, A_2B_2 as examples), spin decoupling
4.5	NMR studies of nuclei other than Proton: ^{13}C Chemical shift and factors affecting it, ^{19}F and ^{31}P NMR.
Suggested Reading Specific to the module	
4.1	Fundamentals of Molecular Spectroscopy, Banwell and McCash, Tata McGraw Hill
4.2	Molecular Spectroscopy, Barrow, McGraw Hill
4.3	Molecular Structure and Spectroscopy, G Aruldas, Prentice Hall.
4.4	Molecular Spectroscopy, K.V. Raman
4.5	Atomic and Molecular Spectroscopy, Gupta

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. A Simple Approach to Group Theory in Chemistry, S Swarnalakshmi, Universities Press
2. Atomic and Molecular Spectroscopy, Gupta
3. Atomic Structure and Chemical Bonding including Molecular Spectroscopy, Manas Chanda.
4. Chemical Applications of Group Theory, F A Cotton, Wiley Eastern.
5. Fundamentals of Molecular Spectroscopy, Banwell and McCash, Tata McGraw Hill
6. Group Theory and Symmetry in Chemistry, L H Hall, Mcgraw Hill.
7. Group Theory in Chemistry, V. Ramakrishnan and M.S. Gopinathan, Vishal Publications
8. Molecular Spectroscopy, Barrow, McGraw Hill.
9. Molecular Spectroscopy, K.V. Raman,
10. Molecular Structure and Spectroscopy, G Aruldas, Prentice Hall.
11. Symmetry in Chemistry, Jaffe and Archin
12. Theory of Atomic Spectra, Sobelman, Alpha
13. Vibrational Spectroscopy, S. Narayana

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Symmetry and Spectroscopy of molecules, K.Veera Reddy, New Age International.
2. Molecular Symmetry and Group Theory, Robert L. Carter, Wiley.
3. Introduction To Magnetic Resonance Spectroscopy ESR, NMR, NQR. N. Sathyanarayana, IK International
4. Group Theory and Its Applications In Chemistry, Salahuddin Kunju, G Krishnan, PHI Learning Pvt. Ltd,

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. List and sketch the different symmetry elements present in benzene molecule. Determine its point group.
2. Find the matrix representation for total movement of water molecule.
3. Reduce the RR 4 1 0 into its component irreducible representations of C_{3V} point group.
4. Discuss rotational spectrum of a polyatomic symmetric top molecule.
5. State and explain Franck – Condon principle.

Semester II	
Electiv Course	
Course Code: **MSCHE02DSE06**	Course Name: **Medicinal Chemistry**

Course Description
Medicinal Chemistry is aimed at students with a strong interest in the biological aspects of chemistry. As well as traditional chemistry topics you will take courses that cover biochemistry, medicines and drug discovery, and the major disease areas. It also works towards improving the whole system that is used to develop the pharmaceuticals. It aims at making new discoveries in drugs and medicines to treat various ailments.

Course Objectives
1. General structural features of agents belonging to the therapeutic class
2. Relevant physicochemical properties
3. Relevant chemical reactions/synthetic pathways for selected drugs
4. Structural influences on mechanism of pharmacologic action (structure-activity relationship)
5. Structural influences on pharmacologic/toxicological/therapeutic profiles. The gained knowledge is the basis for the following courses: Drug Metabolism, Pharmacology and Pharmaceutical Analysis.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	S Recognize the drug structure and predict its pharmacologic action;
C02	Recognize the drug physico-chemical and stereochemical features; Determine the pharmacophore
C03	Describe the mechanism of action, use and mode of application of the selected drugs on the basis of their structure;
C04	Describe and perform synthesis of the drugs and determine the reaction yield.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introductory Medicinal Chemistry**	**12 hrs**
1.1	Concepts of medicinal chemistry	
1.2	Importance of chemistry in pharmacy	
1.3	Molecular pharmacology	
1.4	Physiochemical properties of drugs such as solubility, partition coefficient, ionisation, acidic/basic properties, sterochemical properties.	
	Suggested Reading Specific to the module	
1.1	Medicinal Chemistry, D. Sriram, P. Yogeeswari, Pearson, Education	
1.2	Principals of Organic Medicinal Chemistry, R.R. Nadendla, New Age	
1.3	Basic Pharmacology Cox,F Butterworths	
1.4	Pharmacology and pharmacotherapeutics, Sataskar,R.S Bhandakan, S.D and Ainapure S.S., Popular Prakashan, Mumbai	
2.0	**The Drug chemistry**	**14 hrs**
2.1	Introduction to different classes of drugs, drug action	
2.2	Drug discovery and design, SAR and QSAR, Hansch analysis, Craig plot, Free Wilson analysis, drug delivery systems, Enzyme inhibitors in medicine.	
2.3	Pharacokinetics, drug absorption, distribution, metabolism and excretion, the role of nitric oxide in physiological states	
2.4	General methods of drug synthesis (with paracetamol as eg.), synthesis and action of antibiotics (with penicillin as eg), antiviral agents, general anesthetics	
	Suggested Reading Specific to the module	
2.1	Medicinal Chemistry: classification-synthesis-explanation-mechanism of action-structure activity relationship(SARs)-usages-doses by Ashutosh Kar	
2.2	Medicinal Chemistry introduction by Thomas, Gareth	
2.3	Basic Pharmacology Cox,F Butterworths	

2.4	Pharmacology and pharmacotherapeutics, Sataskar,R.S Bhandakan, S.D and Ainapure S.S., Popular Prakashan, Mumbai
3.0	**Advanced Medicinal Chemistry 13 hrs**
3.1	Applications of Electrophoresis, ultra-filtration, ultracentrifugation in purification, separation and isolation. Introduction to herbal medicine, Introduction the chemistry of homeopathy, Introduction to nanomedicine.
3.2	Organic Medicinal Chemistry: Introduction, general principle of drug action, physico-chemical properties of organic medicinal agents, chemistry of prodrugs, drugs metabolism,
3.3	Chemistry of sedatives, hypnotic drugs (barbiturates and non-barbiturates, introduction to psycho active drugs.
3.4	Introduction to the chemistry of antibiotics
Suggested Reading Specific to the module	
3.1	Principles of organic Medicinal Chemistry by Nadendla,Rama Rao
3.2	Medicinal Chemistry by Patrick,Graham
3.3	Medicinal Chemistry by Yogeeswari.P
3.4	Pharmaceutical Organic Chemistry by Bhasin, S. K
4.0	**Action of Drugs 13 hrs**
4.1	Drug receptors, drug receptor interactions, hydrogen bonding
4.2	Hydrophobic interactions, ionic interactions.
4.3	Structure activity relationships, mechanism of drug action.
4.4	Non specific action of drugs.
Suggested Reading Specific to the module	
4.1	Fundamentals of Medicinal Chemistry, G. Thomas, Wiley
4.2	Introduction to Medicinal Chemistry, G.L. Patrick, Oxford
4.3	Medicinal Chemistry, A. Kar, New Age
4.4	Medicinal Chemistry, An introduction, G. Thomas, Wiley

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Medicinal Chemistry, D. Sriram, P. Yogeeswari, Pearson, Education
2. Principals of Organic Medicinal Chemistry, R.R. Nadendla, New Age
3. Basic Pharmacology Cox,F Butterworths
4. Pharmacology and pharmacotherapeutics, Sataskar,R.S Bhandakan, S.D and Ainapure S.S., Popular Prakashan, Mumbai
5. Principles of organic Medicinal Chemistry by Nadendla,Rama Rao
6. Medicinal Chemistry by Patrick,Graham

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Introduction to Medicinal Chemistry: how drugs act and why by Gringauz, Alex

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. What is phase I biotransformation. Discuss any two oxidative reactions.
2. Write the factors affecting drug metabolism
3. Define biotransformation. What is its importance? Write the sites of biotranformation.
4. Discuss the role of glucouronic acid and glycine in biotransformation.
5. Explain role of Cytochrome P-450 in biotransformation.

Semester II	
Elective Course	
Course Code: **MSCHE02DSE07**	Course Name: **Chemical and Electrochemical Energy Systems**

Course Description
Energy is a fundamental issue facing society world-wide. Electrochemical devices play an important role in energy storage and conversion, especially at certain power-levels. The course will introduce engineering in electrochemical systems while exploring them from the perspective of thermodynamics, kinetics and transport. The course will integrate analysis and design of electrochemical processes by bridging fundamental knowledge from diverse fields, such as electrochemistry, engineering and materials science. It will include fuel cells, electrolyzers, and batteries.

Course Objectives	
1.	To impart knowledge on working and performance evaluation of various energy systems
2.	To facilitate analysis of energy systems using various methods and tools
3.	To study about the new energy systems like fuel cells, hydrogen production and hydrogen storage

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Understand how thermodynamics, kinetics and mass transport apply to electrochemical devices. Understand the nature of the energized electrode and double layers.
C02	Understand the two-electrode/electrolyte nature of electrochemical devices.
C03	Understand the specific construction of several battery and fuel cell systems.
C04	Understand battery and fuel cell charge/discharge and efficiency characteristics

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to chemical & electrochemical energy systems**	**14 hrs**
1.1	Available energy options, their advantages and disadvantages. Environmental effects	
1.2	Comparative evaluation of energy options and energy needs. Fossil fuels: petroleum, natural gas and coal -	
1.3	Origin, processing and production of value added products - available current conversion technologies.	
1.4	Electrochemical power sources - theoretical background on the basis of thermodynamic and kinetic considerations.	
Suggested Reading Specific to the module		
1.1	C. A. Vincent Modern Batteries, Edward Arnold, 1984.	
1.2	K. Sriram, Basic Nuclear Engineering, Wiley Eastern, 1990.	
1.3	D. Linden, Hand book of batteries and Fuel cells, McGraw Hill Book Company, 1984.	
1.4	J.G. Speight, The chemistry and technology of petroleum, Marcel Dekker Inc. (1980).	
2.0	**Electrolyte cells & batteries**	**13 hrs**
2.1	Primary electrolyte cells - various types, especially magnesium and aluminmium based cells - magnesium reserve batteries.	
2.2	Secondary electrolyte cells: classification based on electrolyte type, temperature of operation on the basis of electrodes -	
2.3	chemistry of the main secondary batteries -	

2.4	Batteries for electric vehicles - present status.
Suggested Reading Specific to the module	
2.1	R. Narayanan and B. Viswanathan, Chemical and Electrochemical energy systems, Orient Longmans, 1997.
2.2	D. Linden, Hand book of batteries and Fuel cells, McGraw Hill Book Company, 1984.
2.3	Electrochemical Power Sources: Fundamentals, Systems, and Applications Metal-Air Batteries : Present and Perspectives, by Hajime Arai, Jürgen Garche and Luis Colmenares
2.4	Modern Batteries, by C. Vincent, Bruno Scrosati
3.0	**Fuel cells-I** **13 hrs**
3.1	Fuel cells - classification - chemistry of fuel cells - detailed description of hydrogen/oxygen fuel cells - methanol - molten carbonate,
3.2	Solid polymer electrolyte and biochemical fuel cells.
3.3	Solar energy conversion devices - photovoltaic cells -
3.4	Photoelectrochemical cells - Semiconductor electrolyte junctions photocatalytic modes for fuel conversion process - Photobiochemical options.
Suggested Reading Specific to the module	
3.1	A. S. J.. Appleby and F. K. Foulkes, Fuel cell Hand Book, Von Nostrand Reinhold, 1989.
3.2	Introduction to Fuel Cells Electrochemistry and Materials by San Ping Jiang , Qingfeng Li
3.3	Fuel cells: Principles and applications by Viswanathan
3.4	Fuel Cells: From Fundamentals to Applications by Supramaniam Srinivasan
4.0	**Fuel cells-II** **14 hrs**
4.1	Hydrogen as a fuel production :thermal, electrolysis, photolysis
4.2	Hydrogen as a fuel production photoelectrochemical
4.3	Storage and applications of hydrogen storage.
4.4	Other methods of energy conversion: processes especially in the form of storage as chemical energy.
Suggested Reading Specific to the module	
4.1	T. Ohta, Solar Hydrogen energy systems, Peragamon Press, 1979.
4.2	M. Gratzel, Energy Resources through phtochemistry and catalysis, Academic Press, 1983
4.3	T. Ohta, Energy Technology, Sources, Systems and Frontiers conversions, Pergamon, 1994.
4.4	Hydrogen Storage Technologies, Mehmet Sankir , Nurdan Demirci Sankir

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. C. A. Vincent Modern Batteries, Edward Arnold, 1984.

2. K. Sriram, Basic Nuclear Engineering, Wiley Eastern, 1990.
3. D. Linden, Hand book of batteries and Fuel cells, McGraw Hill Book Company, 1984.
4. J. G. Speight, The chemistry and technology of petroleum, Marcel Dekker Inc. (1980).
5. T. Ohta, Energy Technology, Sources, Systems and Frontiers conversions, Pergamon, 1994.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Fuel Cell Fundamentals by Ryan O'Hayre , Suk-Won Cha , Whitney Colella , Fritz B. Prinz
2. Fuel cells: Principles and applications, B. Viswanathan, Aulice Scibioh Universities Press; 2006
3. Modern Battery Engineering: A Comprehensive Introduction, Kai Peter Birke (Editor), World Scientific Publishing Co Pte Ltd
4. Lithium-Ion Batteries: Basics and Applications, Yuping Wu (Editor), CRC Press;

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. What is the difference between the Fuel cell and batteries?
2. What are the major requirements for an electrolyte in a fuel cell?
4. What is a Fuel cell charge transport resistance?
5. Does temperature have effect on battery?
6. What is stratification in the battery?

Semester II	
Elective Course	
Course Code: **MSCHE02DSE08**	Course Name: **Solid State Chemistry**

Course Description
To introduce the students to the basics of solid state chemistry. Summarize the knowledge in the advanced areas of solid state chemistry such as structure, reactions and phase transition in solids. Relate the electrical, magnetic and optical properties of inorganic compound to its

structures.

Course Objectives	
1.	It is aimed to understand the fundamentals of solid-state chemistry
2.	It is aimed at understanding the properties of solids and their possible applications in materials science as superconductors, liquid crystal materials and as magnetic materials.
3.	Importance has been given to the methods of preparation of solids, understanding the structure-property relationships and their possible applications. Importance has also been given to the advanced topics of nanomaterials.

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Analyze the magnetic properties of different inorganic materials
C02	Describe the origin of the conductivity in superconductors.
C03	Quantify the extent of defects in solids.
C04	Explain the molecular origin of dia-, para- and ferromagnetisms
C05	Explain the applications of liquid crystlas

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to Solid state Chemistry**	**14 hrs**
1.1	Classification of solids, preparation, properties and industrial importance of semiconductors	
1.2	Imperfection in solids, point, line and plane defects, electrons and holes, non-stoichiometry, imperfection and physical properties of solids (brief survey).	
1.3	Electrical properties of solids: electrical conductivity, Hall Effect. Dielectric properties: piezo electricity, ferro electricity and conductivity.	
1.4	Optical properties of solids: photo conductivity, luminescence, color centers, lasers, refraction, birefringence.	
Suggested Reading Specific to the module		
1.1	Introduction to solids, I.V.Azaroof, Mc Graw Hill.	
1.2	Imperfections in crystalline solids, by Cai, Wei , Nix, William D., Cambridge University Press	

1.3	Principles of the solid state, H.V. Keer, Wiley Eastern
1.4	Solid state chemistry and its applications, A.R. West, Wiley
2.0	**Advanced Solid state Chemistry 13 hrs**
2.1	Magnetic properties of solids: diamagnetism, paramagnetism, ferro, antiferro and ferri, magnetisms, calculation of magnetic moments,.
2.2	Mechanical and thermal properties
2.3	Solid state reactions: general principles, Wagner's theory, order-disorder transitions in solids
2.4	Factors influencing the solid state reactions.
	Suggested Reading Specific to the module
2.1	Solid state chemistry, D.K.Chakraharthy, New Age publication
2.2	Solid state chemistry : An introduction, Smart,Lesley, Chapman and Hall
2.3	Solid state chemistry and its applications by West, Anthony R., Wiley
2.4	Electronic structure and the properties of solids : The physics of the chemical bond by Harrison, Walter A., Dover Publications
3.0	**Ionic Conductors and Super conductors 14 hours**
3.1	Ionic Conductors, mechanism of ionic conduction
3.2	Diffusion, superionic conductors
3.3	Phase transitions and mechanism of conduction in superionic conductors,
3.4	Superconductivity, Meisner effects; Type I and II superconductors, high Tc materials.
	Suggested Reading Specific to the module
3.1	Solid state electrochemistry by Bruce, Peter G. Cambridge University press
3.2	New directions in solid state chemistry by Rao, C. N. R , Gopalakrishnan, J. by Cambridge University press
3.3	Solid state chemistry by Rop.R.C., Elsivier
3.4	Advanced Solid State Chemistry, Sanju Kumari, Centrum Publishers.
4.0	**Liquid Crystals 13 hours**
4.1	Liquid Crystals: Types, examples and applications, theories of liquid crystals,
4.2	Photoconductivity of liquid crystals, mesomorphic behaviour, thermotropic liquid crystals, nematic and smectic mesophases, smectic – nematic transition and clearing temperature,
4.3	homeotropic, planar and schlieren textures, twisted nematics chiral nematics, molecular arrangements in smectic A and smectic C phases,
4.4	Optical properties of liquid crystals.
	Suggested Reading Specific to the module
4.1	Liquid Crystals, S. Chandrasekhar, Cambridge University Press
4.2	Condensed matter physics : Crystals, liquids, liquid crystals, and polymers / By: Strobl, Gert R, Springer
4.3	Introduction to Liquid Crystals: Chemistry and Physics, Peter J. Collings, John

	W. Goodby, CRC Press
4.4	Handbook of Liquid Crystals, Fundamentals, Dietrich Demus, Wiley

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Nano-crystalline Ceramics: Synthesis and Structure by Winterer, Markus, Springer
2. Introduction to solids, I.V.Azaroof, Mc Graw Hill.
3. Imperfections in crystalline solids, by Cai, Wei , Nix, William D., Cambridge University Press
4. Principles of the solid state, H.V. Keer, Wiley Eastern
5. Solid state chemistry and its applications, A.R. West, Wiley
7. Solid state electrochemistry by Bruce, Peter G. Cambridge University press
8. New directions in solid state chemistry by Rao, C. N. R , Gopalakrishnan, J. by Cambridge University press
9. Solid state chemistry by Rop.R.C., Elsivier

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Principles of solid state by Keer,H.V. New age Publishers
2. Solid State Physics, A. J. Dekker, Prentice Hall
3. Solid state chemistry: Synthesis,structure, and properties of selected oxides and sulfides by Kirby Dwight.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Explain hysteresis curve for ferromagnetic material.
2. Is dislocation a point defect?
3. What are point defects in solids?
4. What are temporary magnets?
5. Write an essay on the daily life uses of magnets.

Semester II
Elective Course

Course Code:	Course Name:
MSCHE02DSE09	**Polymer Chemistry**

Course Description
The course provides an introduction to polymer chemistry based on classification, structure, properties and synthesis mechanisms of polymers. The course is divided into four modules. The first modules discuss about the basic concepts, classification, nomenclature, molecular weight and distribution of polymers. The second module deals with different polymerization techniques. Third module includes different methods used for the thermal, mechanical and structural characterizations of polymers. Fourth module deals with polymer composites and speciality polymers such as fire-retardant polymers, liquid crystalline polymers, biodegradable polymers, high temperature polymers and optic fibers.

Course Objectives	
1.	To describe classification, structure, and properties of polymers
2.	To understand various types of polymerization techniques and their kinetic and thermodynamic considerations.
3.	To understand various characterization techniques of polymers
4.	To describe different types of polymers and their industrial applications
5.	To correlate the properties and structure of polymers
6.	To learn about learn about speciality polymers and polymer composites

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	To acquire theoretical knowledge and understanding of fundamental concepts, principles and processes of main branches of polymer science.
C02	To understand the concepts of molecular weight of polymers and its determination.
C03	Describe how polymer morphology affects a polymer's overall properties and behavior.
C04	To have awareness on the methods of synthesis, kinetics and thermodynamics of various polymerization processes.
C05	Understand the significance and industrial relevance of polymers

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Classification, structure, and properties of polymers**	**14 hrs**
1.1	Basic Concepts-Classification, nomenclature, molecular weight and distribution, glass transition, morphology	
1.2	Viscosity vs. molecular weight and mechanical property vs. molecular weight relationships, Chain structure and configuration	
1.3	Methods of determination of molecular weight, distribution, size and shape of polymers, Intrinsic viscosity, Mark-Houwink relationship	
1.4	Thermodynamics of polymer solutions, self-diffusion, reptation, Rouse-Bueche theory and de Gennes reptation model.	
Suggested Reading Specific to the module		
1.1	S.R. Sandler, W. Karo, Polymer Synthesis, Vol.2, Academic Press, 1993.	
1.2	S. R. Sandler, W. Karo, Polymer Synthesis, Vol.3, Academic Press, 1998.	
1.3	D. C. Blackley, Polymer Latices, Vol.1, 2 & 3, 2nd Edn., Springer, 1997.	
1.4	W.C. Wake, Analysis of Rubbers and Rubber like Polymers, 2nd Edn, Wiley-Interscience, 1969	
2.0	**Polymerization techniques**	**14 hrs**
2.1	Polymerization techniques: condensation polymerization, kinetic and thermodynamic considerations, molecular weight distribution, chain polymerization: effect of substituents	
2.2	Factors affecting polymerization, methods of polymerization: living polymerization, transfer- radical-polymerization	
2.3	Cationic chain polymerization, kinetics and energetics, anionic polymerization: chain copolymerization, determination of composition, ring-opening polymerization	
2.4	Ziegler-Natta catalyst, control of stereochemistry of polyolefins and polycyclo-olefins. Metathesis polymerization: mechanisms, synthesis of polyacetylenes, synthesis block, graft copolymers	
Suggested Reading Specific to the module		
2.1	D. C. Blackley, Polymer Latices, Vol.1, 2 & 3, 2nd Edn., Springer, 1997.	
2.2	W.C. Wake, Analysis of Rubbers and Rubber like Polymers, 2nd Edn, Wiley-Interscience, 1969	
2.3	F. W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley, 1994.	
2.4	Gowariker et al, Polymer Science. Wiley Eastern, 1990	
3.0	**Characterization techniques of polymers**	**12 hrs**
3.1	Characterization techniques of polymers, Chemical identity using FT-IR, Raman, NMR, GC-MS	
3.2	Thermal, mechanical and structural characterizations of polymers	
3.3	Glass transition temperature and its methods of determination	
3.4	Mechanical properties of polymers and methods of determination	

Suggested Reading Specific to the module	
3.1	Introduction to Physical Polymer Science L. H. Sperling, Wiley- Interscience
3.2	J. Ivin and J. C. Mol, Olefin Metathesis, 2nd edition, Academic Press, 1996.
3.3	Principles of Polymer Chemistry, P. J. Flory, Cornell University Press, 1953.
3.4	Principles of Polymerization G. Odian, Third edition, Wiley-Interscience
4.0	**Speciality polymers & polymer composites 12 hrs**
4.1	Speciality polymers: fire retardant polymers, liquid crystalline polymers.
4.2	Biodegradable polymers, high temperature polymers, optic fibers
4.3	Polymer composites: fibre composites, reinforcing mechanisms
4.4	Failure mechanism in composites, composite fabrication techniques, applications
Suggested Reading Specific to the module	
4.1	D. C. Blackley, Polymer Latices, Vol.1, 2 & 3, 2nd Edn., Springer, 1997.
4.2	W.C. Wake, Analysis of Rubbers and Rubber like Polymers, 2nd Edn, Wiley-Interscience, 1969
4.3	F. W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley, 1994.
4.4	Gowariker et al, Polymer Science. Wiley Eastern, 1990.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. S.R. Sandler, W. Karo, Polymer Synthesis, Vol.2, Academic Press, 1993.
2. D. C. Blackley, Polymer Latices, Vol.1, 2 & 3, 2nd Edn., Springer, 1997.
3. W.C. Wake, Analysis of Rubbers and Rubber like Polymers, 2nd Edn, Wiley-Interscience, 1969
4. F. W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley, 1994.
5. Gowariker et al, Polymer Science. Wiley Eastern, 1990.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. R Introduction to Physical Polymer Science L. H. Sperling, Wiley- Interscience
2. J. Ivin and J. C. Mol, Olefin Metathesis, 2nd edition, Academic Press, 1996.
3. Principles of Polymer Chemistry, P. J. Flory, Cornell University Press, 1953.
4. Principles of Polymerization G. Odian, Third edition, Wiley-Interscience.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1 Describe different methods used for the determination of molecular weight of polymers
2 Explain ring-opening polymerization with suitable example
3 Write a short note on glass transition temperature and its methods of determination.
4 Discuss the mechanism of metathesis polymerization.
5 Write a short note on liquid crystalline polymers

Semester II	
Interdisciplinary Course	
Course Code: **MSCHE02IDC01**	Course Name: **Fundamentals of Pharmaceutical Chemistry**

Course Description
The mission of the Pharmaceutical Chemistry course is to introduce students to the structure, properties, and analysis of pharmaceutical agents and metabolites as well as some fundamental techniques used for near patient testing and pharmacokinetic analysis.

Course Objectives	
1.	To apply pharmacopoeial standards for the preparation of various dosage forms
2.	To identify their professional role in the healthcare system
3.	To classify different dosage forms and apply principles of pharmaceutical science in formulation and dispensing the various dosage forms.
4.	To solve the problem through the application of fundamental principles of pharmaceutical metrology and conclude the decision
5.	To recall the knowledge about modern concept and scope of Pharmacognosy.
6.	To describe the cardiovascular system and lymphatic system

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	develop and demonstrate depth and breadth of knowledge in biomedical, pharmaceutical, social/administrative/behavioral, and clinical sciences.
C02	integrate knowledge from foundational sciences to explain how specific drugs or drug classes work and evaluate their potential value in individuals and populations
C03	apply knowledge in foundational sciences to solve therapeutic problems.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Introduction to Pharmaceutical Chemistry : 15 hrs**
1.1	Importance of Pharmaceutical Chemistry, Posology, Factors affecting drug dose, Introduction & Scope of Human Anatomy & Physiology. Structural & functional organization of cell, its components and functions, Body fluids & its composition. Transport mechanisms across the cell membrane
1.2	Introduction to drugs, Antiviral drugs, Antibiotics, Antineplastic agents, Drugs used in treatment of Bronchial asthma, Drugs used in Congestive Cardiac Failure
1.3	Central Nervous System: Functions of different parts of brain and spinal cord, Neurohumoral transmission in the Central Nervous System, reflex action, electroencephalogram, Physiology and functions of the autonomic nervous system
Suggested Reading Specific to the module	
1.1	David G. Watson. Pharmaceutical Analysis, A Textbook for Pharmacy Students and Pharmaceutical Chemists, 3rd Edition, 2012, Elsevier
1.2	A.J. Winfield, J. A Rees, I. Smith, Pharmaceutical Practice, 4th editions, Elsevier publication. Don A.B. and T.W G. Pharmacy Calculations, CBS Publisher
1.3	Bullock B.L. & Henze R.L. Focus on Pathphysiology, Lippincott Chatterjee, C.C. Human Physiology (Medical Allied Agency, Calcutta)
2.0	**Pharmacognosy and Phytochemistry : 15 hrs**
2.1	Sources and classification of crude drugs, cultivation, collection, processing and storage of crude drugs, importance and factors influencing cultivation of medicinal plant, quality control of crude drugs, adulteration and evaluation.
2.2	Plant tissue of simple and complex and tissue system, morphology of root, stem, bark, wood, leaf, flower, fruit and seed, modification of root, stem and leaf, histology of root, stem and leaf
2.3	Introduction to drug delivery systems, Fast dissolving tablets, effervescent tablets, oral films. Brief about: Oral controlled drug delivery system, Muchoadhesive drug delivery system
Suggested Reading Specific to the module	
2.1	Pharmacognosy: C.K. kokate, A.P. Purohit, S.B. Gokhale, Nirali Prakashan, Pune, 39th edition, 2007.
2.2	Trease and Evan's Pharmacognosy: W.C Evans, W.B. Saunders Co, Singapore, 15th edition 2008
2.3	Pharmacognosy and pharmacobiotechnology, Ashutosh Kar, New Age International Pvt. Ltd. Publishers, 2nd edition,2007

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Gandhi, T.P. Human Anatomy, Physiology & Health Education (B.S. Shah Prakashan,

Ahmedabad)
2. GR Chatwal, Pharmaceutical Chemistry-Inorganic, volume-1, 2nd edition, Himalaya Publishing House, Mumbai, 2005.
3. Pharmacognosy V.E. Tylar, L.R. Brady, J.E. Habbers, Lea and Febgir Philadelphia, 8th edition, 1981
4. Dr.A.V Kasture, De. S.G. Wadodkar, pharmaceutical chemistry-I, 1st edition, Nirali Prakashan, Pune, 1993.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. G. Svehal,Vogel's Qualitative Analysis, 6th edition, Orient Longman Pvt. Ltd, New Delhi,1994
2. Pharmacognosy and phytochemistry, part I and II, Vinod D. Rangari, Carrier Publications, 1st edition, Reprint, 2007.
3. Essentials of Pharmacognosy, S.H Ansari, Birla Publications Pvt. Ltd, 1st edition, 2005-2006.
4. Physicochemical principles of pharmacy, 5th edition, Alexander T. Florence and David Attwood., Pharmaceutical press.
5. Ladu, B.N.,Mandel H.G & E.L Way, Fundamentals of drug metabolism & disposition, William & Wilkins Co. Baltimore

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. What are Antineplastic agents?
2. Discuss the various drugs used in congestive cardiac failure
3. What are the specialties of tablets?
4. Discuss the morphology of plant root

Semester II	
Interdisciplinary Course	
Course Code: **MSCHE02IDC02**	Course Name: **Fundamentals of Geochemistry**

Course Description
Integrates the principle of physics, chemistry and biology to study the dynamics and processes of the earth. Furthermore, the study extends beyond the Earth, encompassing the entire Solar system, i.e. in the study of other planets, the origin of granite, the study of the sun etc

Course Objectives	
1.	To introduce students to applications of chemical concepts to predict the outcome of geologic processes and use of chemical data to solve applied, real-world problems;
2.	To introduce students to basic concepts of geochemistry and several up-to-date issues which are widely discussed in the field of geochemistry;
3.	To orient students to the current status of numerous chemical analysis techniques commonly used in the field of geochemistry;
1.	To provide students with opportunities to use available analytical instruments in the department

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Provide geochemical concepts operating within various spheres in the dynamic earth system.
C02	Illustrate chemical analysis various ore minerals and its applications to mining industries.
C03	Know about the composition of earth, its main components and possible chemical reactions

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Introduction to Geochemistry: 15hrs**
1.1	Introduction: Earth in relation to the universe. The nature and age of the universe, nature and origin of solar system, composition of the universe, sun and planets
1.2	Geochemical cycle. Energy changes in the geochemical cycle. Cosmic abundance of elements.
1.3	Composition of the earth: the internal structure and composition of earth,

	composition of crust. Primary distribution of elements, geochemical classification of elements.
Suggested Reading Specific to the module	
1.1	Brain Mason, Carleton B. Moore (1982): Principles of Geochemistry, 4th edition, John Wiley and Sons Konard B. Krauskopf (1979):
1.2	Introduction to Geochemistry, 2nd edition. Mc Graw Hill publication Stephen F. Mason (1991):
1.3	Geochemistry. Prentice Hall Inc. Faure Gunter, (1986): Principles of Isotope Geology, W.I.E. II edition. U. Ashwatha Narayan, (1985):
2.0	**Chemistry of Geo-materials: 15hrs**
2.1	The hydrological cycle, inter relationship of surface and ground water, physico-chemical properties of water and its structure and bonding.
2.2	Classification and nomenclature of igneous rocks Geochronology, metamorphism, Chemical weathering. Common reactions,
2.3	Microbial degradation or organic matter, Analytical methods. Rock dissolution techniques. Detection of halogens heavy metals and radioactive materials
Suggested Reading Specific to the module	
2.1	Ground water Hydrology. 2nd edition, John Wiley and sons Arthur H. Brownlow (1979):
2.2	Rollinson, H.R., Using geochemical data: Evaluation, Presentation, and Interpretation. Longman (1993).
2.3	Radioactivity in Geology, Principles and Applications. Halsted Press. W. M. White (2007)

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Karanth (1980): Courses in Mining Geology, Second Ed, Oxford and IBH Pub. Co. Todd David Keith (2008): Ground water Hydrology
2 James I Drever (1982): The geochemistry of natural waters- Prentice-Hall
3 Williams J Deutsch- Lewis (1997): Groundwater Geochemistry- Fundamentals and applications

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Arthur W.Rose, Herbert E.Hawkes and John S.Webb, (1979): Geochemistry in Mineral
2 Exploration. 2nd edition. Academic press.
3 A.A.Levinson, (1974): Introduction to Exploration Geochemistry, Applied Publishing Ltd. USA.
4 G.J.S.Govett, (1983):Rock Geochemistry in Mineral Exploration Vol.3. Elsevier Scientific publishing company.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

5. What are the importances of geochemistry?
6. What are the main chemical reactions of geo-materials?
7. What is meant by Chemical weathering?
8. What is the composition of the universe?

Semester II	
Interdisciplinary Course	
Course Code: **MSCHE02IDC03**	Course Name: **Biochemistry in Health and Diseases**

Course Description
Biochemistry in Health and Disease provides a clear and straightforward account regarding the value and benefits of good health and nutrition. Good personal hygiene is one of the best ways to protect ourselves from getting gastro or infectious diseases such as COVID-19, colds and flu. This course offers a general introduction among students regarding the need for hygienic health practices as well as the need for nutrition among the students for a better life, which is needed to build our nation. Besides, this course offers basic ideas about causal agents, symptoms, diagnosis, treatment, prognosis and prevention of various lifestyle disorders among humans.

Course Objectives
1. To generate an idea regarding the importance of health and hygiene among the students.
2. To apprehend the basic concepts of nutrition among the students.
3. To generate awareness about the various diseases which originate and which could be prevented by controlling the life style.
4. To realize general aspects of diagnosis, methods of prevention and pharmaceutical intervention.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End

Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Collect about energy requirements and the Recommended Dietary Allowances.
C02	Analyze the functions and role of macronutrients, their requirements and the effect of deficiency and excess
C03	Identify the impact of various functional foods on our health
C04	To apply basic nutrition knowledge in making foods choices and obtaining an adequate diet.
C05	To summarize various terminologies used in health and disease conditions;
C06	To differentiate between communicable and non-communicable diseases;
C07	To develop health promotion and treatments for various diseases and disorders.

Module	**Course Contents**	**No. of hrs**
1.0	**Health and Nutrition :**	**15 hrs**
1.1	WHO definition of health, Health and hygiene, General health care, Factors affecting health, Indices and evaluation of health, Disease patterns in developed and developing world; Classification of diseases - Endemic, Epidemic, Pandemic; Professional health hazards.	
1.2	Basic Concepts of Nutrition: Introduction, Basic principles of a balanced diet to provide energy and nutrients. Composition of foods and proximate analysis of foods. Calorific value of foods.	
1.3	Basal Metabolism, Basal Metabolic Rate (BMR), Factors affecting BMR, Energy requirements for different physical activities, Specific dynamic action of food, Nutritive value of proteins. Energy requirements and recommended dietary allowance (RDA) for infants, children and pregnant women. Protein calorie malnutrition.	
Suggested Reading Specific to the module		
1.1	Modern Nutrition in Health and Disease 2006 10th Edition by Maurice E. Shils, Moshe Shike, A Catharine Ross.	
1.2	Clinical Dietetics and Nutrition, 2002, Antia FP and Abraham P. Oxford University Press; 4th Edition. ISBN-10: 9780195664157.	
1.3	Oxford Handbook of Nutrition and Dietetics, 2011, Webster-Gandy J, Madden A and Holds worth M. Oxford University Press, Print ISBN-13: 9780199585823	
2.0	**Lifestyle Disease:**	**15 hrs**
2.1	Concept of lifestyle diseases- importance of lifestyle factors in preventing disease development, diet, exercise, smoking, alcohol etc.	
2.2	Major Lifestyle disorders: Obesity, Liver cirrhosis, Diabetes mellitus, Hypertension (Causative agents, symptoms, diagnosis, treatment, prognosis,	

	prevention).
Suggested Reading Specific to the module	
2.1	Clinical Biochemistry and Metabolic Medicine, 2012 Eighth Edition by Martin Andrew Crook, CRC Press,
2.2	M. Kumar R. Kumar, Deep and Deep Publications, Guide to Prevention of Lifestyle Diseases

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Oxford Handbook of Nutrition and Dietetics, 2011, Webster-Gandy J, Madden A and Holds worth M. Oxford University Press, Print ISBN-13: 9780199585823.
2. Krause's Food, Nutrition and Diet therapy, 2003, Mahan KL and Escott-Stump S. Elsevier, ISBN: 9780721697840.
3. Human Nutrition and Dietitics. 1986, Passmore R. and Davidson S. Churchill Livingstone Publications, ISBN-10: 0443024863.
4. Rosemary Stanton's Complete Book of Food & Nutrition, 2007, Simon & Schuster Publishers, Australia, ISBN 10: 073181299

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Cliff Nyambichu (Author), Jeff Lumiri (Editor) Format: Kindle Edition, Lifestyle Diseases: Lifestyle Disease Management Kindle Edition.
2. https://www.intechopen.com/books/11710

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Differentiate between endemic, pandemic and epidemic diseases.
2. Explain the importance of managing life style diseases.
3. Explain how diet is corelated with the life style diseases.
4. Importance of lifestyle factors in preventing disease development
5. Explain the role of dietary supplement in infants and children.

Semester II	
Skill Enhancement Course	
Course Code:	Course Name:

MSCHE02SEC01	Good Laboratory Practices

Course Description
This course deals with different aspects of good laboratory practices. The importance of implementing good laboratory practices is to ensure quality in test data, good management of laboratory with regards to quality, reliability, integrity of studies and traceability of data. The course discusses the basic operations and practices that should be followed routinely in all chemical laboratories

Course Objectives	
1.	To introduce the students about the safe practices, basic laboratory procedures and protocols for a job laboratory situation.
2.	To orient students about safe handling of chemicals and glass wares and to take precaution against accidents by following safety measures.
3.	To practice minimization of errors related with handling of laboratory accessories and equipment's.
4.	To learn Standard Operating Procedures (SOPs) Laboratory equipment's
5.	To learn how to record, keep and analyze laboratory data with accuracy.
6.	To provide students with opportunities to use available analytical instruments in the department

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Develop skill in safe-handling of chemicals and laboratory equipment.
C02	Understand the safely practices, basic laboratory procedures and protocols for a job laboratory situation.
C03	Understand the precautions to be taken to avoid lab accidents by following the safety measures
C04	Avoid random usage of dangerous chemicals and use chemicals in a judicious way
C05	Maintain laboratory records and audit records with current industry standards
C06	Understand the basic calibration and handling of basic laboratory instruments

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No of Hrs
1.0	**Good laboratory practices – 1:**	**15hrs**
1.1	General rule and protocols for lab safety measures, precaution and safety in handling of chemicals, laboratory tools, glass wares and instruments. Maintenance and cleaning of laboratories.	
1.2	Personal Protective and other safety equipment and their uses: various safety goggles, types of gloves, apron, masks, different filters for masks, face shield, full body suit, safety shoes. Eye wash fountains and safety showers. Procedure for working with gases at pressure above or below atmospheric.	
1.3	Fire extinguishers and their periodic inspection. First aid kit, its contents and need for monitoring. Emergency exit, its location and approach path. Spills, injuries, fires, building evacuations, emergencies. Fire drill and chemical accident drills. Accident recording and investigation for future controls	
1.4	Safe storage and use of hazardous chemicals. Waste Management: waste classification, hazardous waste, non-hazardous waste, mixed waste. Safe storage and disposal of chemical waste.	
Suggested Reading Specific to the module		
1.1	Handbook Good Laboratory Practices Good Laboratory Practices (GLP) quality practices for regulated non-clinical, research and development.	
1.2	Good laboratory practice standards: Applications for field and Laboratory Studies (ACS Professional Reference Book) by Willa Y. Garner, Manureen S. Barge and James P.	
1.3	Good laboratory practice standards: Applications for field and Laboratory Studies (ACS Professional Reference Book) by Willa Y. Garner, Manureen S. Barge and James P.	
1.4	Chemical Safety matters ─ IUPAC ─ IPCS. Cambridge Univ. Press, 1922.	
2.0	**Good laboratory practices – 2:**	**15hrs**
2.1	Preparation of standard solution and buffers. Calibration of instruments: pH meter, colorimeter, spectrophotometer, water bath, distillation assembly, burette, pipette etc.	
2.2	Reliability of analytical data: Errors in chemical analysis, classification of errors, determining the accuracy of methods, improving accuracy of analysis, statistical analysis, rejection of results, presentation of data	
2.3	Maintenance of internal and external audit, log book maintenance, basic SOPs for instrument handling and maintenance	
Suggested Reading Specific to the module		
2.1	Principles of Instrumental Analysis" by Douglas A. Skoog, James Holler, Stanley R. Crounch	
2.2	Fundamentals of Analytical Chemistry" by Douglas A Skoog, Donald M, West Holler Thomson	
2.3	Willard, Hobert H. et. al: Instrumental Methods of Analysis, 7th Ed. Wardsworth	

	Publishing Company, Belmont, California, USA, 1988

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Guidelines for good laboratory practices-Indian council of medical research, New Delhi (2008)
2. Chemical Laboratory Safety and Security: A Guide to Prudent Chemical Management, Lisa Moran and Tina Masciangioli, Editors, The National Academies Press Washington,
3. Safety in Academic Chemical Laboratory, Vol. II, ACS Publication, 7th Edition (2003).
4. Analytical chemistry by Gary D. christian, John wiley & son
5. Instrumental Methods of Chemical Analysis by Chatwal and Anand

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. A Primer for Good Laboratory Practices and Good Manufacturing Practices, L. Huber, Agilent Technologies, 2002.
2. Handbook of Good Laboratory Practices, TDR, WHO, UNICEF, UNDP (2009).
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry New Age, International Publisher, 2009
4. Instrumental Methods of Chemical Analysis by B.K. Sharma

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. What are the different personal protective equipment used in laboratories?
2. Write a short note about the safe storage and disposal of chemical wastes.
3. What are the different types of errors in chemical analysis?
4. Discuss the SOP for operation and calibration of a pH Meter.

Semester II	
Skill Enhancement Course	
Course Code: **MSCHE02SEC02**	Course Name: **Scientific Writing**

Course Description

Scientific writing is a skill that is useful for science students, since many of them will write about their research in a thesis, dissertation, or in journal articles. The goal of my course is to provide students with practice and training in scientific writing so that after they take the course, they are confident and ready to write drafts independently.

Course Objectives	
1.	This course aims to demystify the writing process and teach the fundamentals of effective scientific writing.
2.	Instruction will focus primarily on the process of writing and publishing scientific manuscripts. Further give a brief introduction in ethics in publications.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Understand basic principles of scientific writing for both specialized and non-specialized audiences
C02	Argue persuasively for a research idea using references to published research
C03	Know how to apply the IMRD structure in the production of a research article
C04	Correctly use and reference source material according to journal standards
C05	Understand the publication process

Module	**Course Contents**	**No. of hrs**
1.0	**Introduction to Scientific Writing:**	**15 hrs**
1.1	Introduction: Components of a research paper– the IMRD system, title, authors and addresses, abstract, acknowledgements, references, tables and illustrations. Use of automated referencing software (Mendley, EndNote, etc.), reference style- Harward and Vancavour system.	
1.2	When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Citation and Acknowledgement, ISBN & ISSN. Peer review.	
1.3	Introducing various Publishers (Nature, Plos One, Elsevier, Springer, etc.), Understanding essential terms (Citations, Impact factor, h-index and i10-index), Selecting appropriate journal to publish an article. Preparing Manuscript, dealing with publishers – submission of manuscript, ordering reprints. Basic formats of thesis and writing thesis, Oral and poster presentation of research papers in	

	conferences/symposia. Preparation and submission of research project proposals to funding agencies. Redundant publication: duplication and overlapping of publications, selective reporting and misinterpretation of data.
Suggested Reading Specific to the module	
1.1	Alley, Michael, and others. Writing Guidelines for Engineering and Science. Pennsylvania Stat
1.2	How to Write and Publish a Scientific Paper, 7th Edition, by Robert A. Day, Barbara Gastel
1.3	Alred, Gerald J., Charles T. Brusaw, and Walter E. Oliu. Handbook of Technical Writing. 10th ed. Boston: Bedford/St. Martin's, 2011. Easy Guide to Science and Technical Writing: A guide to writing articles for peer reviewed journals, Graham Andrews
2.0	**Publication ethics and Open access: 15 hrs**
2.1	Publication ethics: definition, introduction and importance, Best practices/ standards setting initiatives and guidelines: COPE (Committee on Publication Ethics) WAME (World Association of Medical Editors) etc. Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types. Violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals.
2.2	Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies. Software tool to identify predatory publications. Journal finder/journal suggestion tools viz. JANE (Journal/Author Name Estimator), Elsevier Journal Finder, Springer Journal Suggester, etc. Presentation tools: oral and poster, Microsoft Power Point and PDF slides.
Suggested Reading Specific to the module	
2.1	Philosophy of Science Routledge. MacIntyre, Alasdair (1967) A Short History of Ethics. London, P. Chaddah (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN: 978-9387480865.
2.2	Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN: 978-81-939482-1-7.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Barrass, Robert. Scientists Must Write: A Guide to Better Writing for Scientists, Engineers, and Students. 2nd ed. New York: Routledge, 2002.
2. Benson, Philippa J., and Susan C. Silver. What Editors Want: An Author's Guide to Scientific Journal Publishing. Chicago: University of Chicago Press, 2013.
3. Blum, Deborah, Mary Knudson, and Robin Marantz Henig, eds. A Field Guide for Science Writers: The Official Guide of the National Association of Science Writers. 2nd ed. New York: Oxford University Press, 2006.

4. Coghill, Anne M., and Lorrin R. Garson, eds. The ACS Style Guide: Effective Communication of Scientific Information. 3rd ed. New York: Oxford University Press, 2006.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. https://sites.pitt.edu/~gveser/Ethics/ How To Give A Presentation. Pdf Bird, A. (2006).
2. Resnik, D.B. (2011). What is ethics in research and why is it important. National Institute of Environmental Health Science, 1-10.
3. https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
4. Beall, J. (2012).Predatory publishers are corrupting open access. Nature, 489 (7415) 179-179. https://doi.org/10.1038/489179a

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce, practical

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Explain IMRD in scientific publication.
2. Differentiate between Plagiarism and Self-Plagiarism
3. What are major types of scientific publishers available to publish the article?
4. How to make an effective scientific publication?

Semester II	
Skill Enhancement Course	
Course Code: **MSCHE02SEC03**	Course Name: **Separation and Purification Techniques**

Course Description
This subject deals with the application of the science and engineering science that you have learned to the separation of chemical and biological mixtures. Specific processes considered will include chromatography and adsorption.

Course Objectives	
1.	The main objective of this course is to familiarize students with the fundamental principles of separation processes used in analytical chemistry such as various extraction techniques, gas and liquid chromatography, size and ion chromatography.

2.	By completion of the course, students are also expected to gain independent laboratory skills in certain separation techniques and they will have the ability to interpret data from analytical separation methods.

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Identify the importance of solvent extraction method.
C02	Acquire a critical knowledge on separation techniques.
C03	Demonstrate skills related to Chromatographic techniques through hands on experience.
C04	Demonstrate the usage of common laboratory apparatus used in quantitative analysis
C05	Able to engage in safe and accurate laboratory practices by handling laboratory glassware, Equipment and chemical reagents appropriately.
C06	Comprehend the applications of Chromatographic techniques in different fields.

Module	Course Contents	No. of hrs
1.0	**Separation techniques in Chemical analysis:**	**20 hrs**
1.1	Solvent Extraction: Introduction, principle, techniques, factors affecting solvent extraction, Batch extraction, continuous extraction and counter current extraction. Synergism. Ion Exchange: Introduction, action of ion exchange resins, separation of inorganic mixtures, applications	
1.2	Classification of chromatography methods, principles of differential migration adsorption phenomenon, Nature of adsorbents, solvent systems, Rf values, factors effecting Rf values. Paper Chromatography: Principles, Rf values, experimental procedures, choice of paper and solvent systems, developments of chromatogram-ascending, descending and radial. Two dimensional chromatography, applications.	
Suggested Reading Specific to the module		
1.1	Solvent Extraction Classical and Novel Approaches ,Vladimir S Kislik · 2011, Solvent extraction in analytical chemistry By George H. Morrison · 1957	
1.2	Chemical Analysis: Modern Instrumentation Methods and Techniques, Francis Rouessac, Annick Rouessac, John Wiley & Sons, 2nd ed, 2007.	
2.0	**Chromatography Technique 2 :**	**10hrs**
2.1	Thin layer Chromatography (TLC): Advantages. Principles, factors effecting Rf values. Experimental procedures. Adsorbents and solvents. Preparation of plates. Development of the chromatogram. Detection of the spots. Applications.	

2.2	Column Chromatography: Principles, experimental procedures, Stationary and mobile Phases, Separation techniques, Applications. HPLC: Basic principles and applications.
Suggested Reading Specific to the module	
2.1	Principles and practice of Analytical Chemistry, F.W. Fifield and D. Kealeg, Blackwell publications
2.2	Fundamentals of Analytical Chemistry by Douglas A. Skoog; Donald M. West; F. James Holler; Stanley R. Crouch

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Principles of quantitative chemical analysis, de Levine, Mc Graw Hill
2. Vogel's Qualiitative Inorganic Analysis, Pearson Education
3. Vogel's Quantitative chemical analysis, Pearson Education
4. Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole
5. Principles of Instrumental Analysis by Douglas A. Skoog; F. James Holler; Stanley R. Crouch

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Modern Analytical Chemistry, David Harvey, McGraw-Hill, 1st ed, 2000, ISBN: 0–07–237547–7
2. Principles of Instrumental Analysis", D. A. Skoog, F. J. Holler, S.R. Crouch, Brooks Cole; 6th edition (Dec 6 2006) , ISBN: 0495012017 , 978-0495012016
3. Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
4. Analytical Chromatography by G.R. Chatwal

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce, practical

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Outline the principle involved in Solvent extraction.
2. Write a brief note on Synergism.
3. How can you classify the Chromatographic methods?
5. Discuss the basic principle involved in HPLC

6. What are stationary and mobile phases?

Semester II	
Value-Added Course	
Course Code: **MSCHE02VAC01**	Course Name: **Advanced Techniques for Characterization of Materials**

Course Description
Characterizations of materials are essential for the applications of the same in various fields of material science. This is also important in diverse fields, which includes chemical, microstructure and physical properties of different materials used as probes, sensors and in medical fields.

Course Objectives
The aim of the course is to provide the students with an overview of sophisticated instrumentation techniques emphasized with special reference to the principles, practice and applications of UV-Visible spectroscopy, X-ray diffraction, thermal and electrochemical techniques.

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
2	0	2	30	0	30	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Explain the principles and operation of a range of advanced techniques such as UV-Visible spectroscopy, X-ray diffraction, thermal and electrochemical instruments used in characterization of various materials.
C02	Develop an idea about the crystal structure of materials and their by its structure - property relations.
C03	Understanding, from a microstructural point of view, the thermal properties of materials and related applications.
C04	Hand on experience of instruments and interpretation of results. Apply the skills gained in research and industrial explores

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Spectroscopic and X-ray Techniques**	**15 hrs**
1.1	Theory of Ultraviolet and Visible Spectroscopy: Internal conversion, conical intersection, Principle, solvent effects,	
1.2	Instrumentation and applications of UV-Visible, spectroscopy, FT-IR Raman and Fluorescence spectroscopy, Practical: Hands on experience of operation with UV-Vis-, Raman and data analysis	
1.3	Theory: Principle, Theory- X-ray spectral lines, instrumentation, Powder XRD and Single crystal XRD	
1.4	X-ray Diffraction, Analysis with X-ray diffraction, applications. Practical: Instrumentation, sampling and hands on experience with instruments for analysis.	
Suggested Reading Specific to the module		
1.1	Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin,IBH-Oxford.	
1.2	Introduction to Spectroscopy, Pavia, Brooks/ColeCenage,4thedition,2009,Belmont.	
1.3	Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole	
1.4	Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Inter science. Elements of X-ray diffraction by B. D. Cullity	
2.0	**Thermal and Electrochemical Studies**	**15 hrs**
2.1	Thermo gravimetric methods of analysis (TGA): Instrumentation, applications TGA for quantitative analysis and problems based TGA. Differential Scanning Calorimetry (DSC): Principle, Instrumentation, Applications	
2.2	Practical: Instrumentation, sampling, Hands on experience of operation with DSC and TGA and interpretation of Data	
2.3	Coulometric methods of analysis. Voltammetric principles, hydrodynamic voltammetry, stripping voltammetry, Cyclicvoltammetry (CV), Principle, application and interpretation of cyclic voltammograms	
2.4	Practical: Instrumentation, working, samplings, hands on experience of operation CV and data analysis	
Suggested Reading Specific to the module		
2.1	Thermal Analysis From Introductory Fundamentals to Advanced Applications by El-Zeiny Ebeid, Mohamed Zakaria, Thermogravimetric Analysis by Jesse Russell, Ronald Cohn	
2.2	Introduction to Thermal Analysis: Techniques and Applications: 1 (Hot Topics in Thermal Analysis and Calorimetry) by M.E. Brown	
2.3	Fundamentals of electroanalytical chemistry (analytical techniques in the sciences) by Paul M.S. Monk	
	Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West	

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West
2. Principles of Electroanalytical Methods by Tom Riley, Colin Tomlinson
3. Fundamentals of electroanalytical chemistry (analytical techniques in the sciences) by Paul M.S. Monk
4. Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West
5. Elements of X-ray diffraction by B. D. Cullity
7. Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Principles of Electroanalytical Methods by Tom Riley, Colin Tomlinson
2. Fundamentals of Analytical Chemistry, Skoog, West, Holler, Croach, Thomson Brooks/Cole
3. Instrumental methods of chemical analysis, Willard, Dean and Merrit, Affiliated East West Press
4. Basics Of X Ray Diffraction And Its Applications by K Ramakanth Hebbar
5. Principles and Applications of Thermal Analysis by Paul Gabbott

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Discuss the principle of X Ray crystallography.
2. Write down the Debye Scherrer formula for calculating grain size.
1. Briefly explain the principle of X Ray Fluorescence.
3. What are the advantages of ATR over other IR sampling techniques?
6. Distinguish between TG, DTG and DTA?

Semester III	
Core Course	
Course Code:	Course Name:

MSCHE03DSC08	Progressive Organic Chemistry

Course Description
The course describes progressions in organic chemistry, mainly the characterization of organic compounds using sophisticated spectroscopic techniques. The use of UV-Visible spectroscopy, InfraRed spectroscopy, NMR and mass spectroscopy are explained in details for the elucidation of organic compounds. Problems based on the above techniques are illustrated. Use of new reagents in organic synthesis is added. An introductory study of the chemistry of natural product is also included.

Course Objectives	
1.	To make the student aware about the modern methods of organic synthesis
2.	To introduce the UV spectroscopic techniques
3.	To learn the IR spectroscopy
4.	To study the NMR spectroscopy of organic molecules
5.	To apply the fractionalization of organic molecules by Mass spectrum
6.	To learn how to elucidate the structure of organic compounds using spectroscopic techniques
7.	To learn about the natural product chemistry
8.	To study the latest organic reaction techniques

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	know about the UV spectroscopy, its effects on various parameters such as solvents, substitution, etc
C02	get information about the infrared spectroscopy, the factors influencing vibrational frequencies, sample techniques, solvents and group frequencies
C03	get knowledge about the applications of IR spectroscopy, quantitative infrared analysis, Attenuated Total Reflectance and Multiple Internal Reflectance spectroscopy
C04	familiar with Proton and 13 Carbon NMR spectroscopy, its applications to organic chemistry
C05	study the theory and instrumentation of Mass spectroscopy
C06	determine the structure of an organic compound based on the combinations of

	spectroscopic techniques.
C07	have an idea about the Extraction and isolation of natural products, Hofmann, Emde and von Braun degradations
C08	digest Blanc's rule, Barbier-Wieland degradation. Oppenuer oxidation, Diel's hydrocarbon, biosynthesis of terpenes and alkaloids
C09	get an idea about the modern organic methods of synthesis

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Basic Organic Spectroscopy 18 hrs**
1.1	Ultraviolet and visible spectroscopy: sampling, solvent effects, limitations, applications, Woodward-Fieser method of calculations.
1.2	Infrared spectroscopy: factors influencing vibrational frequencies, sample techniques, solvents, group frequencies, applications,
1.3	Quantitative infrared analysis, Attenuated Total Reflectance, Photo-Aquoustic Spectroscopy, Multiple Internal Reflectance spectroscopy,
1.4	Proton NMR spectroscopy: Chemical shift, spin-spin splitting and coupling constants, applications to organic compounds, coupling of proton to other nuclei (^{19}F, ^{15}N, ^{31}P, ^{29}Si)
1.5	Structural elucidation problems based on UV-Visible, InfraRed and NMR spectroscopies
Suggested Reading Specific to the module	
1.1	Introduction to Organic Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz and James A. Vyvyan, Cengage India Private Limited;
1.2	Spectroscopy of Organic Molecules: Fundamental Problems and their Solution, J.P. Mahashabde, J.P. Sonawane, R.B. Chaudhari, K.A. Pawara, H.S. Kulkarni and K.H. Patil, Notion Press
1.3	Modern Techniques of Spectroscopy Basics Instrumentation and Applications, Singh D.K., Springer
1.4	Modern Infrared Spectroscopy, Barbara Stuart, Bill George, Peter McIntyre, Wiley India Pvt. Ltd
1.5	Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C. Smith, CRC Press
2.0	**Advanced Organic Spectroscopy 18 hrs**
2.1	Carbon-13 NMR spectroscopy: off-resonance and proton decoupling, Nuclear Overhauser Effect, applications
2.2	Advanced NMR techniques: DEPT, HMQC and HSQC techniques, ESR spectroscopy
2.3	Structural elucidation of organic compounds based on ^{1}H-NMR and ^{13}C-NMR. Structural elucidation of organic compounds based on IR and ^{1}H-NMR spectral

	data
2.4	Mass spectroscopy: Theory and instrumentation, Fragmentations, application studies, McLafferty rearrangement
2.5	Structural elucidation of organic compounds based on UV, IR, NMRs and MS data
Suggested Reading Specific to the module	
2.1	Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler, T.C. Morril, John Wiley
2.2	Understanding Nmr Spectroscopy, Keeler James, John Wiley
2.3	Organic Structures from Spectra, L D Field, H.L. Li, A.M. Magill, Wiley
2.4	Introduction to Organic Mass Spectrometry, Siddiqui Anees A CBS Publishers
2.5	Organic structural spectroscopy, J.B. Lambert, H.F. Shurvell, D.A. Lightner and R.G. Cooks, Prentice hall
3.0	**Chemistry of Natural Products 18 hrs**
3.1	Extraction and isolation of natural products, Hofmann, Emde and von Braun degradations in alkaloid chemistry,
3.2	Classification of Terpenoids, isoprene rules, general methods of determining the structure of terpenoids,
3.3	Introduction to steroids, Blanc's rule, Barbier-Wieland degradation. Oppenuer oxidation, Diel's hydrocarbon,
3.4	Biosynthesis of terpenes and alkaloids.
3.5	Analytical techniques to investigate structures, developing drugs from natural products; chemistry of key natural products
Suggested Reading Specific to the module	
3.1	Chemistry of Natural products, Sujata V. Bhat, BA nagasampagi, M. Shivakumar, Narosa publishing
3.2	Total Synthesis of Natural Products: At the Frontiers of Organic Chemistry, Editors: Jie Jack Li, E.J. Corey, Springer
3.3	Natural Product Chemistry, K.S. Jain, S.B. Gaikwad, H.H. Puranik, Nirali Prakashan
3.4	Natural products chemistry, R.R Wedekar, M.R Raut, Everest publishing house
3.5	Organic chemistry of natural products, O.P Qgarwal, Krishna Pralkash
4.0	**Modern Synthetic Organic Chemistry 18 hrs**
4.1	Retrosynthetic Analysis: Basic principles and terminology of retrosynthesis, synthesis of aromatic compounds, one group and two group C-X disconnections,
4.2	One group C-C and two group C-C disconnections, amine and alkene synthesis, important strategies of retrosynthesis,
4.3	Transition metal catalysts in organic synthesis, introduction to Combinatorial chemistry and Click chemistry, Fundamentals of Supramolecular Chemistry Functional group transposition, important functional group inter-conversions

4.4	Reagents in organic synthesis: Boron, sulphur, phosphorous, Silicon, Mercury and cadmium containing reagents
4.5	Organometallic reagents in organic synthesis, Platinum and palladium reagents, Oxidation and Reduction reagents,
Suggested Reading Specific to the module	
4.1	Organic Synthesis, The disconnection Approach, Stuart Warren, , Paul Wyatt, Wiley
4.2	Organic Synthesis Through Disconnection Approach, P S. Kalsi, Med Tech
4.3	Organic Chemistry A Mechanistic Approach, Chaloner P, CRC Press
4.4	Application of Transition Metal Catalysts in Organic Synthesis, H. D. Verkruijsse, L. Brandsma, and S.F. Vasilevsky, Springer
4.5	Reagents for High-Throughput Solid-Phase and Solution-Phase Organic Synthesis, Jonathan A. Ellman , John Wiley, 2005

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Organic Spectroscopy William. Kemp, Plagrave publishers
2 Organic Spectroscopy, Jag Mohan , Narosa Publishing House
3 Organic Spectroscopy (NMR, IR, Mass and UV), S.K. Dewan, Atithi Books
4 Chemistry Of Natural Products, Solomon K Anand, MJP Publisher
5 Natural Products Research Review Vol. 1, Gupta, V K, Daya Publishing House
6 Click Chemistry: Diverse Chemical Function from a Few Good Reactions, H. C. Kolb; M. G. Finn; K. B. Sharpless (2001). Angewandte Chemie International Edition

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Spectroscopy Of Organic Compounds, P S Kalsi, New Age International (P) Ltd
2 Organic Spectroscopy by Pradeep Pratap Singh Ambika, Viva Books
3 Guide to Organic Spectroscopy, Dipti K. Dodiya, Clever Fox Publishing
4 Thiol–Ene Click Chemistry, Hoyle, Charles E.; Bowman, Christopher N. (2010). Angewandte Chemie International Edition. 49 (9): 1540–1573. doi:10.1002/anie. 200903924
5 Customizable Generation of Synthetically Accessible, Local Chemical Subspaces. Pottel, J.; Moitessier, N. (2017). J. Chem. Inf. Model. 57 (3): 454–467. doi:10.1021/acs.jcim. 6b00648
6 Supramolecular Chemistry. Lehn, J. (1993). Science. 260 (5115): 1762–23, doi: 10.1126/ science.8511582
7 Supramolecular Chemistry - Fundamentals And Applications: Advanced Textbook by Ariga Katsuhiko Et. Al, Springer

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Why ethanol is considered as the best solvent for UV analysis?
2. An organic compound with molecular formula C8H10O2. Absorbs in UV at 260 nm. It has IR absorptions at 3035, 2937, 1582, 1530, 1465, 1203, 1112 and 659 cm^{-1}. Determine the structure of the molecule
3. What is Nuclear Overhauser Effect? What are its applications?
4. An organic compound with molecular formula $C_4H_{10}O_2$, shows IR transmittance at 3520, 2960, 2899, 1440, 1100 cm^{-1}. It has ^{1}H-NMR peaks at 1.22 (d, 6H), 2.32 (dq, 2H) and 4.49 (s, 2H). Sketch the structure of the compound.
5. Explain the von Braun degradations in alkaloid chemistry
6. Discuss the general methods of determining the structure of terpenoids

8 Discuss the importances of click chemistry.

9 Discuss the applications of retrosynthetic analysis

SEMESTER III	
Core Course	
Course Code: **MSCHE03DSC09**	Course Name: **Advanced Bioinorganic Chemistry**

Course Description
This course introduces the students a general over view of the fundamental aspects performed by inorganic elements in living materials. The learners will also understand the role of metal ions and inorganic complexes in biological process including metal toxicity as well as the application of inorganic complexes as therapeutics. This course will give a strong foundation to carry out research on metallo enzyme application, inorganic biomaterial and pharmaceutical development. It also offers the students a platform to focus on how cells transform energy by producing, storiong or consuming Adenosine Tri phosphate (ATP).

Course Objectives

1.	The learners should be able to realize and recognise the significance of metal and nonmetal ions in various aspects of biological system.
2.	To identify the coordination complexes with respect to their role in living organisms, active site structure and functions of some transition metal ion containing metalloproteins or enzymes.

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Evaluate the principles of transition metal coordination complexes in understanding their functions in biological systems
C02	Contrast the principles of transition metal coordination complexes in understanding their functions of plants
C03	Illustrate the significance of metal chelators used as drugs for various diseases, their methods of synthesis.
C04	Compare and contrast the role of Mn, Ni, Mo, Co, Al, Li, Cr and Zn in biology
C05	Recognize the metalcenters involved in oxygen transport in living organism and comprehend the mechanism of this process.
CO6	Discuss the basic principles in inorganic and general chemistry in bioinorganic chemistry.

* Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to bioinorganic Chemistry**	**18 hrs**
1.1	Introduction to Bioinorganic Chemistry, Elementary cell biology, Distribution of inorganic elements in biological systems. Essential and beneficial metal ions.	
1.2	Elements of life: Water, sugars, polysaccharides, amino acids, peptides, proteins, nucleosides, nucleotides, nucleic acids, lipids and phosphates. Protein synthesis and DNA replication. Coordination sites in biologically important ligands.	
1.3	Role of metal ions in biological functions. Biological role of some trace non-metals (B, Si, S, Se, As, Cl, Br, I), Biological importance of nitric oxide. Biomineralisation. Model compounds in biochemical studies – Biomimicry.	
1.4	Transport of ions across membranes: ionophores, active and passive transport, Na^+/K^+ pump in biological system. Structural role of calcium, transport of	

	calcium, intra and extra cellular calcium binding, role of calcium in blood clotting.
Suggested Reading Specific to the module	
1.1	Inorganic Biochemistry, G.L. Eichhom(Ed), Vol. 1 and 2, Elsevier, 1973.
1.2	Bioinorganic Chemistry, L. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, Univ. Science Books, 1994.
1.3	Bioinorganic Chemistry, R.W. Hay, Ellis Harwood, 1984.
1.4	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.
2.0	**Role of metal ions in biological systems-I 18 hrs**
2.1	Iron in biological systems, Haemoglobin (Hb) and myoglobin (Mb), transport of oxygen by heme proteins, co-operativity of oxygen binding, reversible oxygen binding, binding of CO to Hb and Mb, haemerrythrin
2.2	Functions of prosthetic groups, designing of synthetic blood. Storage and transport of metal ions: ferritin, transferrin, siderophores. Iron enzymes, cytochromes and their roles in biological systems.
2.3	Cytochrome P_{450} and the mechanism of its activity. Copper in biological systems: ceruloplasmin, copper in oxidase activity, superoxide dismutase
2.4	structure and functions of haemocyanin, azurin, plastocyanin, Type I, II and III copper protein models.
Suggested Reading Specific to the module	
2.1	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.
2.2	Inorganic Biochemistry, G.L. Eichhom(Ed), Vol. 1 and 2, Elsevier, 1973.
2.3	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.
2.4	Bioinorganic Chemistry, L. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, Univ. Science Books, 1994.
3.0	**Role of metal ions in biological systems-II 18 hrs**
3.1	Role of Mn, Ni, Mo, Co, Al, Li, Cr and Zn in biology: metalloproteins as enzymes, metalloenzymes and metal activated enzymes, Zn(II) and Mg(II) containing enzymes
3.2	Zn-finger proteins, carbonic anhydrase, alcohol dehydrogenase, catalase, peroxidase, redox enzymes, DNA and RNA polymerase, DNA intercalators, vitamins and co-enzymes, vitamin B_{12}, metal toxicity and hemostasis.
3.3	Diseases caused by excess and deficiency of metal ions, metals in medicine, metal ion based drugs (Pt, V and Au), metal ions as diagnostic agents, MRI imaging and contrast agents, toxicity due to non-essential elements and speciation.
3.4	Chelation theory and chemotherapy, metal detoxification mechanism,

	thermodynamic and pharmacokinetic properties of chelating drugs in metal detoxification.
Suggested Reading Specific to the module	
3.1	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.
3.2	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.
3.3	Bioinorganic Chemistry, L. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, Univ. Science Books, 1994., Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.
3.4	Bioinorganic Chemistry, R.W. Hay, Ellis Harwood, 1984.
4.0	**Bioenergetics 18 hrs**
4.1	Bioenergetics: ATP and phosphate group transfer - a source of metabolic energy, ATP cycle and phosphate group transfer
4.2	functions of pyruvate kinase and creatine kinase, porphyrins (H_2P) and metalloporphyrins (MP): spectral, fluorescence and redox properties of H_2P and MP, picket-fence porphyrin.
4.3	Chlorophyl: PS I and PS II, model systems of water splitting and CO_2 reduction
4.4	Biological nitrogen fixation: nitrogenase, Fe-S clusters, Fe-protein structure, P-cluster and M-centre, nitrogenase model system.
Suggested Reading Specific to the module	
4.1	Principles of Biochemistry, A. L. Lehninger, D. L. Nelson and M. M. Cox, CBS Publishers and Distributors, 1993
4.2	Bioinorganic Chemistry, R.W. Hay, Ellis Harwood, 1984.
4.3	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980
4.4	Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Inorganic Biochemistry, G.L. Eichhom(Ed), Vol. 1 and 2, Elsevier, 1973.

2 Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson, 6thEd., Wiley, 1999.

3 Biocoordination Chemistry, D. E. Fenton, (Chemistry Primer 26), Oxford Univ. Press, 1995.

4 Bioinorganic Chemistry, L. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, Univ. Science Books, 1994.

5 Bioinorganic Chemistry, R.W. Hay, Ellis Harwood, 1984.

6 Concepts and Models of Inorganic Chemistry, B. E. Douglas, D. McDaniel and J. Alexander, Wiley, 2013.

7 Inorganic chemistry – A Unified Approach, W.W. Porterfield, Academic Press, 1993.

8 Metal ions of Biological Systems, H. Siegel and T. G. Spiro, Marcel-Dekker, 1980.

9 Principles of Biochemistry, A. L. Lehninger, D. L. Nelson and M. M. Cox, CBS Publishers and Distributors, 1993.
10 Principles of Bioinorganic Chemistry, S. J. Lippard & J. M. Berg, Univ. Science Books.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Metal in Biochemistry, P.M. Harrison and R.J. Hoare, Chapman and Hall, 1980.
2 The Inorganic Chemistry of Biological Processes, M.N. Hughes, Wiley, 1981.
3 Bioinorganic chemistry, Asim K. Das, Books & Allied (P) Ltd.2013
4 Bioinorganic and Supramolecular chemistry, P.S Kalsi and J.P Kalsi, New age International Publishers, 2008

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Differentiate between Essential and beneficial metal ions.
2. Discuss the binding of CO to Hb and Mb, haemerrythrin
3. Illustrate the Role of Mn, Ni, Mo, Co in biology.
4. Explain LCAO Biological nitrogen fixation
5. Discriminate the functions of pyruvate kinase and creatine kinase

Semester III	
Core Course	
Course Code: **MSCHE03DSC10**	Course Name: **Chemical Kinetics and Catalysis**

Course Description
This course deals with the fundamentals of homogeneous and heterogeneous reaction engineering processes. This course will also provide a theoretical background and modeling tools to understand experimental and theoretical aspects of chemical reaction kinetics. The course is divided into four modules. The first modules discuss about the rate law, kinetics of complex reactions and theory of unimolecular reactions. The second module deals with collision and transition state theories of reaction rates and factors affecting reaction rates in solutions. Third module includes kinetics and mechanisms of homogeneous and

heterogeneous catalysis as well as enzyme catalysis. Fourth module deals with the kinetics of surface catalyzed reactions and catalysis by metals and semiconductors.

Course Objectives	
1.	To impart fundamental knowledge about the basic concepts of chemical kinetics.
2.	To provide conceptual framework for understanding molecular reaction dynamics
3.	To understand the link between reaction rates and rate constant.
4.	To study the application of mathematical tools to calculate the kinetic properties of a reaction.
5.	To impart knowledge of applications of catalysis

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Acquire knowledge on the mechanism of chemical reactions for optimizing the experimental conditions.
C02	Conduct quantitative analysis of kinetic data of chemical reactions
C03	Explain the origin of observed kinetics for simple chemical reactions
C04	Rationalize the application of homogeneous and heterogeneous catalysts in chemical synthesis
C05	Know the importance of catalytic activity at the solid surfaces

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Chemical Kinetics -I**	**24 hours**
1.1	Rate law equation: significance, determination of order of a reaction: differential, integral, isolation and half-life methods, true and false orders	
1.2	Determination of rate coefficient of a first order reaction by Guggenheim's methods, kinetics of complex reactions: reversible, parallel and consecutive first order reaction	
1.3	Theory of unimolecular reactions: Lindmann theory, steady state approximation principles, reaction involving free radicals and reactive atoms, Rice-Herzfeld mechanism	
1.4	Chain reaction, branching chains, explosion, Hinshelwood mechanism of chain	

	reactions and explosion.
1.5	Thermal decomposition of organic compounds, the HI formation.
Suggested Reading Specific to the module	
1.1	Chemical Kinetic Methods: Principles of Relaxation Techniques and applications, C. Kalidas, New Age International
1.2	Chemical Kinetics, K.J. Laidler, Pearson Education
1.3	Kinetics and Mechanisms of Chemical Transformations, J. Rajaram and J.C. Kuriacose, Macmillan
1.4	Physical Chemistry, Atkins, P.W., W.H. Freeman, Oxford University
1.5	Chemical Kinetics, K.J. Laidler, Pearson Education
2.0	**Chemical Kinetics -II 24 hours**
2.1	Theories of reaction rate: Collision theory, transition state theory, comparison and limitations of the two theories, the kinetic and thermodynamic parameters: Significance of entropy of activation
2.2	Arrhenius equation and its temperature dependence of frequency factor, Potential energy surfaces. Salt effect: primary and secondary salt effects
2.3	Influence of solvent on reaction rates. Fast reactions: Relaxation method, flow method, flash photolysis and magnetic resonance method
2.4	Reactions in solution: Factors affecting reaction rates in solutions, effect of dielectric constant and ionic strength, cage effect, Bronsted-Bjerrum equation
Suggested Reading Specific to the module	
2.1	Physical Chemistry, Atkins, P.W., W.H. Freeman, Oxford University
2.2	Chemical Kinetics, K.J. Laidler, Pearson Education
2.3	Chemical Kinetic Methods: Principles of Relaxation Techniques and applications, C. Kalidas, New Age International
2.4	Chemical Kinetics, K.J. Laidler, Pearson Education
3.0	**Catalysis-I 14 hours**
3.1	Kinetics and mechanisms of homogeneous and heterogeneous catalysis, autocatalytic reactions
3.2	Catalytic promoters and catalytic inhibitors, acid base catalysis, acid functions
3.3	Enzyme catalysis: influence of substrate concentration: single substrate: Michaelis-Menten equation, and double substrate reactions
3.4	Kinetics of inhibition, effects of pH, temperature, on enzyme catalyzed reactions and its applications
Suggested Reading Specific to the module	
3.1	Heterogeneous Catalysis by Thomas & Thomas
3.2	Physical Chemistry, Atkins, P.W., W.H. Freeman, Oxford University
3.3	Modern Heterogeneous Catalysis: An Introduction, Rutger A. van Santen, Wiley-VCH
3.4	Heterogeneous Catalysis Fundamentals and Applications,1st Edition, Julian R.H.

	Ross, Elsevier
4.0	**Catalysis-I** **10 hours**
4.1	Kinetics of surface catalyzed reaction: Langmuir Hinshelwood and Rideal model
4.2	Catalysis by metals, electronic factors of catalysis by metals, Balandin's multiplet theory, Valence angle conservation mechanism
4.3	Structure-sensitive and structure-insensitive reactions, charge transfer theory of catalysis by metals, effect of the electronic structure of metals on chemisorption and catalysis
4.4	Catalysis by semiconductor, boundary layer theory of chemisorption, Wolkenstein's theory of catalysis by semiconductors, Ammonia synthesis and oxidation of CO
Suggested Reading Specific to the module	
4.1	Physical Chemistry, Atkins, P.W., W.H. Freeman, Oxford University
4.2	Metal Oxides in Heterogeneous Catalysis,Jacques C. Vedrine, Elsevier
4.3	Heterogeneous Catalysis by Thomas & Thomas
4.4	Physical Chemistry, Atkins, P.W., W.H. Freeman, Oxford University

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Chemical Kinetic Methods: Principles of Relaxation Techniques and applications, C. Kalidas, New Age International
2. Chemical Kinetics, K.J. Laidler, Pearson Education
3. Fundamentals of Photochemistry, K.K. Rohatgi - Mukkerjee, Wiley Eastern Ltd.
4. Introduction to Molecular Dynamics and Chemical Kinetics G.D. Billing and K.V. Mikkelsen, John Wiley
5. Kinetics and Mechanisms of Chemical Transformations, J. Rajaram and J.C. Kuriacose, Macmillan
6. Molecular Reaction Dynamics and Chemical Reactivity, R.D. Levine, R.B. Bernstein Oxford
7. Reaction Kinetics, M.J. Pilling and P.W. Seakins, Oxford Univ. Press
8. The Principles of Electrochemistry, D.R. Crow, Chapman and Hall
9. Heterogeneous Catalysis by Thomas & Thomas
10. Metal Oxides in Heterogeneous Catalysis, Jacques C. Vedrine, Elsevier
11. Modern Heterogeneous Catalysis: An Introduction, Rutger A. van Santen, Wiley-VCH

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Physics and Chemistry of Surfaces by Adamson
2. Kinetics and Mechanisms, J. W. Moore & R.G. Pearson, John Wiley & Sons,
3. The theory of Rate Process, S. Glasstone, K. J. Laidler and H. Eyring, McGraw Hill.
4. Physical Chemistry, R. A. Albert and R. J. Silby, Wiley Eastern
5. Heterogeneous Catalysis Fundamentals and Applications,1st Edition, Julian R.H. Ross, Elsevier

6. Physical Chemistry, Atkins, P.W., W.H. Freeman, Oxford University

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Explain parallel reactions with suitable examples.
2. Write a short note on consecutive reactions.
3. Explain the collision theory of reaction rate.
4. Discuss the mechanism and kinetics of homogeneous catalysis.
5. Explain the boundary layer theory of chemisorption for semiconductor-catalyzed surface reactions.

Semester III	
Core Course	
Course Code: **MSCHE03DSC11**	Course Name: **Physical Chemistry Practical**

Course Description
This course is intended to acquaint the students with the practice of experimental physical chemistry. To apply the principles of thermodynamics, kinetics and spectroscopy presented in the physical chemistry lecture courses, in some illustrative experiments. To understand the interconnection between experimental foundation and underlying theoretical principles and to appreciate the limitations inherent in both theoretical treatments and experimental measurements.

Course Objectives	
1	To make the students expertise in the applied concepts of kinetics, electrochemistry, thermodynamics, phase equilibrium, adsorption, etc.
2	To make the students draw structures and graph using software's analysis and prepare reports

Credit	**Teaching Hours**	**Assessment**

L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
0	4	4	0	288	288	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	Interpret data from an experiment, including the construction of appropriate graphs and the evaluation of errors.
C02	Construct the Freundlich and Langmuir isotherms for adsorption of acetic/oxalic acid on active charcoal/ alumina and determine the concentration of acetic/ oxalic acid.
C03	Construct the phase diagram and determine the composition of an unknown mixture.
C04	Construct the ternary phase diagram of acetic acid chloroform-water system and out the procedure in an unfamiliar situation to find out the composition of given homogeneous mixture.
C05	Construct the tie-line in the ternary phase diagram of acetic acid chloroform-water system.
C06	Determine distribution coefficient using distribution law.
C07	Determine Kf of solid solvent, molar mass of non-volatile solute, mass of solvent and composition of given solution.
C08	Determine surface tension and parachor of liquids.
C09	Ascertain the relationship between surface tension with concentration of a liquid and use this to find out the composition of given homogeneous mixture.
C10	Determine the concentration of given strong acid/alkali.
C11	Determine the heat of ionisation of acetic acid.
C12	Interpret data from an experiment, including the determine the strength of strong/ weak acids by conductometric titration.
C13	Verify Onsager equation and Kohlraush's law conductometrically .
C14	Determine the activity and activity coefficient of electrolyte.
C15	Determine the concentration of a solution potentiometrically or pH metrically.
C16	Employ spectrophotometry in determining unknown concentration.
C17	Determine the viscosity of liquid mixtures and use this in determining the concentration of a component in a mixture.
C18	Determine the concentration of a liquid mixture using a refractometer.
C19	Determine the unknown concentration of a given glucose solution.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	
1.0	**Distribution methods**	**54 hrs**

1.1	Distribution law: Partition of iodine between water and carbon tetrachloride
1.2	Equilibrium constant of simple reaction
1.3	Concentration of unknown KI, partition studies
1.4	Determination of equilibrium constant, hydrolysis constant, association studies, Solid and liquid equilibria:
Suggested Reading Specific to the module	
1.1	A Text Book of Quantitative Inorganic Analysis, A.I. Vogel, Pearson Education
1.2	Experimental Inorganic Chemistry, W.G. Palmer, Cambridge University Press.
1.3	Experimental Physical Chemistry, D.P. Shoemaker and C.W. Garland, McGraw-Hill.
1.4	Experimental Physical Chemistry, F. Daniels and J.H. Mathews, Longman.
2.0	**Phase Equilibria studies 54 hrs**
2.1	Construction of phase diagram of simple eutectics, systems with congruent melting points and solid solutions, determination of composition of unknown mixtures, analytical and synthetic methods for the determination of solubilities and heat of solution.
2.2	Partially miscible liquids: Critical solution temperature, influence of impurities on the miscibility temperature, determination of composition of unknown mixtures.
2.3	Completely miscible liquid systems: Construction of phase diagrams of two component liquid systems, Zeotropic and azeotropic.
2.4	Three component systems: With one pair of partially miscible liquids, construction of phase diagrams and tie lines, compositions of homogenous mixtures, heat of solution from solubility data, analytical and graphical method.
Suggested Reading Specific to the module	
2.1	Practical Physical Chemistry by M. Satish Kumar
2.2	Practical Physical Chemistry by B. Viswanathan
2.3	Advanced Practical Physical Chemistry by J.B. Yadav
2.4	Physical Chemistry Practical by Saroj Kumar Maity, Naba Kumar Ghosh
3.0	**Molecular weight determination & Refractometry 54 hrs**
3.1	Molecular Weight Determination, Rast and transition temperature method, molecular weight of a solid using a solid solvent by cooling curve method.
3.2	Molecular weight determination by study of depression in transition temperature, cryoscopic study.
3.3	Refractometry: Determination of molar refractions of pure liquids, determination of composition of mixtures.
3.4	Viscosity: Determination of viscosity of pure liquids, composition of binary liquid mixtures determination of molecular weight of a polymer.
Suggested Reading Specific to the module	
3.1	Experimental Physical Chemistry, D.P. Shoemaker and C.W. Garland, McGraw-

	Hill.
3.2	Experimental Physical Chemistry, F. Daniels and J.H. Mathews, Longman.
3.3	Experimental Physical Chemistry, V.d. Ahuwale and parul, New age International.
3.4	Instrumental Methods of Analysis, H.H. Willard, L.L. Merritt and J.A. Dean, AEWt Press.
4.0	**Electrochemical and spectrochemical studies 54 hrs**
4.1	Potentiometry: Electrode potentials of Zn and Ag electrodes, determination of standard potentials, determination of mean activity co-efficient of an electrolyte at different molalities by EMF method, dissociation constant measurement, determination of strength of a given solution, potentiometric titration.
4.2	Flame photometry: quantitative determination of Na^+, K^+, Li^+ and Ca^{2+} ions Polarography: determination of number of components and concentration (Cd^{2+}, Zn^{2+}, Pb^{2+}, Cu^{2+}, etc.) Kinetics of salt effect
4.3	Determination of Transport number Conductance study of saponification reaction Potentiometry: determination of stability constant of Cu^{2+} and ethelenediamine UV-Vis. Spectrophotometer: determination of the order of a reaction Colorimetry: quantitative determination of the components of a binary mixture
4.4	Computer applications in chemistry a) Chem draw/ ISIS sketches for reaction and mechanism (minimum 3 Nos) b)C^{++} programming for the calculation of thermodynamic parameters
Suggested Reading Specific to the module	
4.1	Experimental Physical Chemistry, D.P. Shoemaker and C.W. Garland, McGraw-Hill.
4.2	Experimental Physical Chemistry, F. Daniels and J.H. Mathews, Longman.
4.3	Experimental Physical Chemistry, V.d. Ahuwale and parul, New age International.
4.4	Instrumental Methods of Analysis, H.H. Willard, L.L. Merritt and J.A. Dean, AEWt Press.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. A Text Book of Quantitative Inorganic Analysis, A.I. Vogel, Pearson Education
2. Experimental Inorganic Chemistry, W.G. Palmer, Cambridge University Press.
3. Experimental Physical Chemistry, D.P. Shoemaker and C.W. Garland, McGraw-Hill.
4. Experimental Physical Chemistry, F. Daniels and J.H. Mathews, Longman.
5. Experimental Physical Chemistry, V.d. Ahuwale and parul, New age International.
6. Instrumental Methods of Analysis, H.H. Willard, L.L. Merritt and J.A. Dean, AEWt Press.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Practical Physical Chemistry A M James, J A Churchil
2. Practical Physical Chemistry, A. Finlay and J. Akitchener, Longman
3. Practical Physical Chemistry, D.M. James and F.E. Prichard, Longman

Teaching Learning Strategies

- Practical, Viva Voce

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Determine the molecular weight of given solute A by transition temperature method using naphthalene as solvent
2. Determine the composition of the given mixture (glycerol-water) using Ostwald viscometer method
3. Determine the composition of the given mixture (benzene-acetic acid-water) using phase rule
4. Determine the concentration of given mixture ($K_2Cr_2O_7$ & $KMnO_4$) colori metric method
5. Determine the concentration of HCl using conductometric titration method (HClX NaOH)

Semester III	
Core Course	
Course Code: **MSCHE03DSC12**	Course Name: **Industry Visit**

Course Description
Industrial visits are usually the first point of interaction between a student and a live working industry. The students learn about the latest technology trend and make up their minds about their future job or area of interest

Course Objectives
1. To make the students to have an opportunity to interact with Industry experts such as professionals, entrepreneurs: 2. To provide an insight into the real working environment, workstations, plants, assembly lines, machines, systems, and interact with highly trained and experienced personnel.

Credit	**Teaching Hours**	**Assessment**

L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
0	2	2	0	0	0	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	know the functioning of the industry, how the machine parts work, what principles they follow, how much time it will take to complete the process, how the workers manage the work properly

Semester III	
Elective Course	
Course Code: **MSCHE03DSE10**	Course Name: **Electro Chemistry, Electrodics and Phase Equilibria**

Course Description
The ideas of Gibbs free energy, electron transport, and chemical transformation will all be combined to help you comprehend electrochemistry. You will study the fundamental ideas behind acid-base reactions and their connection to chemical equilibrium in this course. The importance of electrochemistry will be explained, along with the connections between mechanical, chemical, and electrical energy. The course gives idea about the different phases of matter and their equilibria from which the stability and sustainability can be easily predicted

Course Objectives	
1.	To develop an understanding of non-ideality of electrolyte solutions and its effect on equilibrium constants, electrolyte solutions and solution conductivity.
2.	Learn about the thermodynamics of electrochemistry, the structure of the electrode/electrolyte interface and electrode processes.
3.	To know about the phase rule and its application in 3 component system.
4.	Defines phase, equilibrium, component, degree of freedom and phase rule concepts.
5.	Applies above mentioned concepts to the field of Materials Science and Engineering. Relates these concepts.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	To understand theories of electrolytes and electrochemical reactions.Ascertain the application of electrochemistry in industrial fields.
C02	Understand the theories and applications behind various types of analytical techniques in electrochemistry. Describe the reactions occurring in an electrochemical (voltaic) cell
C03	Acquire the knowledge in Phase composition and rule, Understand the significance of electrochemistry, how it relates to other fields of science, and how it is applied in real life
C04	Acquire skill in solving numerical problems. Defines the importance of Phase Diagrams in the field of materials science. Explains the basic definitions and terms in a phase diagram.

Course outcomes based on revised Blooms taxonomy

Module	**Course Contents**	**No. of hrs**
1.0	**Electrochemistry-I**	**20 hrs**
1.1	Ionic nobilities, influence of pressure and temperature on ion conductance, Walden's equation, abnormal ion conductance.	
1.2	Derivation of Debye-Huckel-Onsager equation, validity of Debye-Huckel-Onsager equation for aqueous and nonaqueous solution.	
1.3	conductance ratio and Onsager equation, dispersion of conductance at high frequencies, Debye-Falken effect.	
1.4	Debye-Huckel limiting law and its various forms and qualitative and quantitative tests, osmotic coefficient, ion association and dissociation constant, tripple ion and conductance minima, equilibria in electrolytes.	
1.5	Solubility product principle, solubility in presence of common ion, activity coefficient and solubility measurement.	
Suggested Reading Specific to the module		
1.1	Introduction to Electrochemistry, S. Glasstone, D. Van Nostrand.	
1.2	Modern Electrochemistry, J.O.M. Bockris and A.K.N. Reddy, Plenum	
1.3	Physical Chemistry, Daniels and Alberty, John Wiley.	
1.4	The Principles of Electrochemistry, D. A. Mc Innes, Dover Publishers	
2.0	**Electrochemistry-II**	**14 hrs**
2.1	Equilibrium Electrochemistry: Electrode potential. electrochemical cell, Concentration cell.	
2.2	Thermodynamic properties from EMF data, Activity and activity coefficient	

	determination for electrolytes,
2.3	Ion selective electrodes, Determination of pH, Glass electrode
2.4	Potentiometric titration, Redox indicators, Storage cells
Suggested Reading Specific to the module	
2.1	The Principles of Electrochemistry, D.R. Crow, Chapman and Hall
2.2	Theoretical electrochemistry, L.I. Anthropov, Mir publishers.
2.3	Thermodynamics for chemists, S. Glasstone, Affiliated East West publication
2.4	Thermodynamics, Lewis and Randall, Mc Graw Hill.
2.5	D. R. Crow, Principles and Applications of Electrochemistry, Blackie Academic and Professional, 4th Edn., 1994.
3.0	**Electrodics** **10 hrs**
3.1	Dynamic electrochemistry: Electrical double layer electric capillary, Lippmann potential, membrane potential.
3.2	Electrolytic polarization, dissolution and decomposition potential, concentration polarization.
3.3	Theories of over voltage, Hydrogen and Oxygen over voltages, Butler-Volmer equation for simple electron transfer reaction.
3.4	Exchange current density, Tafel equation and its significance.
Suggested Reading Specific to the module	
3.1	J.O.M. Bokris and A.K.N. Reddy, Modern Electrochemistry, Plenum Press, 1973.
3.2	Introduction to Electrochemistry, S. Glasstone, D. Van Nostrand.
3.3	Modern Electrochemistry, J.O.M. Bockris and A.K.N. Reddy, Plenum
3.4	Physical Chemistry, Daniels and Alberty, John Wiley.
4.0	**Phase Equilibria** **10 hrs**
4.1	Phase equilibria, criteria, derivation of phase rule.
4.2	Two component systems: Euetectic systems, System with congruent melting point, compounds with incongruent melting point, solid solutions, systems with partially miscible solid phase, liquid phase are partially miscible,
4.3	Introduction to three-component system and its graphical representation, hydrate formation, compound formation.
4.4	Thermal evaporation, transition point and double salt formation, salting out effect, liquid- liquid equilibria
Suggested Reading Specific to the module	
4.1	An Introduction to chemical thermodynamics, Rastogi and Misra, Vikas publishing.
4.2	G.W. Castellan, Physical Chemistry, Addison-Lesley Publishing
4.3	Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis by Mats Hillert
4.4	Phase Equilibria: Basic Principles, Applications, Experimental Techniques

	By Arnold Reisman

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. An Introduction to chemical thermodynamics, Rastogi and Misra, Vikas publishing.
2. G. W. Castellan, Physical Chemistry, Addison-Lesley Publishing
3. B. K. Sharma, Electrochemistry, Krishna Prakashan, 1985.
4. Introduction to Electrochemistry, S. Glasstone, D. Van Nostrand.
5. Modern Electrochemistry, J.O.M. Bockris and A.K.N. Reddy, Plenum
6. Physical Chemistry, Daniels and Alberty, John Wiley.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Puri, Sharma, Pathania, Principles of physical Chemistry Vishal publishing company, 2013.
2. Gurdeep Raj Advanced Physical Chemistry GOEL Publishing House, Meerut, 2004.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. State Debye-Huckel limiting law. Calculate the activity coefficient of sodium ions and the mean ionic activity coefficient of 0.01M aqueous solution Na_2SO_4 at room temperature.
2. Write a note on triple ion formation and conductance minima.
3. What is electrophoretic effect? Derive an expression for electrophoretic effect.
4. Derive Debye-Huckel-Onsager equation and discuss the validity of the same.
5. What is relaxation? Derive an expression for relaxation effect for a strong electrolyte in solution.

SEMESTER III	
ELECTIVE COURSE	
Course Code: **MSCHE03DSE11**	Course Name: **Biomaterials**

Course Description

The course provides a platform to evaluate and explain the relations between enzyme properties, catalytic mechanism, reaction types and application in relevant biocatalytic conversions. Learners will recognize the different biomolecules and their structure. The course helps to gain an over view of biomaterials in medical field and to aquire knowledge on physicochemical properties and characterization of biomolecules.

Course Objectives	
1.	Considered as one of the molecular sciences, biochemistry is a branch of both chemistry and biology; The main goal of biochemistry is to understand the structure and behavior of biomolecules.
2.	To introduce the role of biochemistry in our daily life.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Discus knowledge of biomolecules in living systems.
C02	Memorise the structure of DNA, RNA and their types.
C03	Asses basic consepts of structural organization and characterization of proteins.
C04	Describe the interactions of bacteria with biomaterials and methods for sterilization
C05	Appraise common use biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology.
C06	Describe general structure and function of cells, extracellular matrix and tissue.
C07	Apply and account for methods to characterise interactions between materials and tissue

* Course outcomes based on revised Blooms taxonomy

Module	**Course Contents**	**No. of Hrs**
1.0	**Chemistry of biomolecules**	**13 hrs**
1.1	Cell structure: Chemistry of biomolecules, basic aspects of structure and classification of carbohydrates	
1.2	lipids, aminoacids, proteins and nucleic acids	
1.3	Supramolecular assemblies, biomembranes	
1.4	Lipo and glycoproteins	

Suggested Reading Specific to the module	
1.1	Biochemistry, Christopher K. Mathews and K. E. Von Holder, Benjamin/ Cummings.
1.2	Design Engineering of Biomaterials for Medical Devices, David Hill, John Wiley and Sons
1.3	Biochemistry, Lubert Stryer, W. H. Freeman and Company, 4th edition.
1.4	Biomaterials: Principles and applications, J.B. Park, J.D. Bronzino, CRC Press
2.0	**Biocatalysis 14 hrs**
2.1	Biocatalysis, concept of enzyme catalysis, role of vitamins and metals as cofactors, enzyme kinetics, Michaelis-Menten equation
2.2	inhibition of enzyme action, regulatory aspects, Metabolism: Overview and important relationships between-glycolysis
2.3	TCA cycle, HMP shunt, oxidation of fatty acids, amino acids and urea cycle
2.4	Flow of genetic information, nature of genetic code, replication of DNA, transcription and translation, regulation of gene expression.
Suggested Reading Specific to the module	
2.1	Fundamentals of biochemistry New York: John Wiley & Sons2008
2.2	Biochemistry, Lubert Stryer, W. H. Freeman and Company, 4th edition
2.3	Biomaterials: Principles and applications, J.B. Park, J.D. Bronzino, CRC Press
2.4	Biochemistry, Christopher K. Mathews and K. E. Von Holder, Benjamin/Cummings
3.0	**Bioactive polymers and ceramics 13 hrs**
3.1	Bioactive and biodegradable polymers: bioactive ceramics. Biocompatibility, toxicity, cytotoxicity, hypersensitivity
3.2	Protein interaction with synthetic materials. Immunological responses to biomaterials
3.3	blood compatibility, platelet adhetion and aggregation, coagulation
3.4	Assessment of blood: compatibility, sterility and infection.
Suggested Reading Specific to the module	
3.1	Design Engineering of Biomaterials for Medical Devices, David Hill, John Wiley and Sons
3.2	Biochemistry, Christopher K. Mathews and K. E. Von Holder, Benjamin/Cummings.
3.3	Biomaterials: Principles and applications, J.B. Park, J.D. Bronzino, CRC Press, Biomaterial Science- An introduction to Materials in Medicine, B.D. Ratner, A.S. Hoffman, F.J. Schoen and J.E. Lemons, Academic press
3.4	Principles of Biochemistry Albert L. Lehninger, David L. Nelson, Michael M. Cox., CBS Publishers and Distributors.
4.0	**Biomaterials 14 hrs**
4.1	Interactions of bacteria with biomaterials, methods for sterilization, assessment

	of sterility
4.2	Cardiovascular applications: grafts, catheters, stents, valves, embolic agents,
4.3	orthopedic applications-joint prostheses, fracture fixation devices
4.4	ophthalmologic applications, contact lenses, corneal implants, Dental materials and implants
Suggested Reading Specific to the module	
4.1	Principles of Biochemistry Albert L. Lehninger, David L. Nelson, Michael M. Cox., CBS Publishers and Distributors.
4.2	Design Engineering of Biomaterials for Medical Devices, David Hill, John Wiley and Sons
4.3	Biochemistry, Lubert Stryer, W. H. Freeman and Company, 4th edition
4.4	Biochemistry, Garrett, Reginald, and Charles Grisham.. Nelson Education, 2012

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Biochemistry, Christopher K. Mathews and K. E. Von Holder, Benjamin/Cummings.
2. Biochemistry, Lubert Stryer, W. H. Freeman and Company, 4th edition.
3. Biomaterial Science- An introduction to Materials in Medicine, B.D. Ratner, A.S. Hoffman, F.J. Schoen and J.E. Lemons, Academic press
4. Biomaterials: Principles and applications, J.B. Park, J.D. Bronzino, CRC Press
5. Principles of Biochemistry Albert L. Lehninger, David L. Nelson, Michael M. Cox., CBS Publishers and Distributors.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Biochemistry (2 Volume Set): The Chemical Reactions of Living Cells Metzler, David E.. Elsevier, 2003.
2. Biochemistry: a short course. Tymoczko, John L., Jeremy M. Berg, and Lubert Stryer.. Macmillan, 2011.
3. Biochemistry, Garrett, Reginald, and Charles Grisham.. Nelson Education, 2012.
4. Fundamentals of biochemistry Voet, Donald, Judith G. Voet, and Charlotte W. Pratt.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Describe the structure and classification of carbohydrates, lipids, aminoacids
2. Differentiate Bioactive and biodegradable polymers
3. Discuss the various methods for sterilization
4. Explain Michaelis-Menten equation
5. Comprehend the various applications of biomaterials in medical field.

Semester III	
Elective Course	
Course Code: **MSCHE03DSE12**	Course Name: **Forensic Chemistry & Toxicology**

Course Description
Forensic study is an interdisciplinary field of study that encompasses the essence of all science courses, including Chemistry, Biology, Physics, and Mathematics. It is mostly used to recognize, identify, analyze, and testify to any type of physical evidence uncovered at crime scenes.

Course Objectives	
1.	Learn about the drugs and its abuse with their various identification techniques.
2.	The students shall also learn regarding various types of poison, their nature, action sign & symptoms with standard procedure of examination in poisoning cases.
3.	Gain knowledge about ADME of poisons and methods of collection and preservation of evidences.
4.	Understand the basics of Forensic Chemistry & Toxicology, their scope, role & significance.

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	to understand the various types of drugs, commonly abused along with their presumptive & instrumental analysis
C02	know the legal provisions & Forensic investigation regarding drugs, cosmetics, fire and arson evidences
C03	know medicolegal aspect of poisons and the management of toxicological cases

C04	Understand the principles of management of toxicological cases.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to Forensic Chemistry**	**14 hrs**
1.1	Role of Forensic Chemist, Types of Cases which require Chemical Analysis, Sampling of Evidences, Presumptive Tests (Colour/Spot Tests), Microcrystal Tests	
1.2	Limitations of Forensic Samples, Elemental Analysis (Organic and Inorganic), Instrumental Methods and Equipment. Examination of Contact Traces	
1.3	Introduction to Cosmetics and Detective Dyes, Collection, Sampling, Analysis and Forensic Importance. Analysis of Illicit Liquors including Methyl and Ethyl Alcohol	
1.4	Drugs of Abuse: Introduction, Drug Addiction and its Problems. Classification of Drugs of Abuse, Analgesics, Depressants, Stimulants, Hallucinogens and Narcotics	
Suggested Reading Specific to the module		
1.1	Brown, W. Drinking, Drugs & Driving Drunk: How Different Drugs Affect the Driving Experience 2nd ed. William Gladden Foundation Press: (2011).	
1.2	Connors, K.A. A text book of Pharmaceuticals Analysis 2nd ed. Wiley: New York; (1975).	
1.3	Clarke, E.G.C. and Moffat, A.C. Clarke's Isolation and Identification of Drugs: In Pharmaceuticals, Body Fluids and Post Mortem Material. Pharmaceutical Press: (1986).	
1.4	Crown. D.A. The Forensic Examination of Paints and Pigments. Thomas (1968).	
2.0	**Instrumentation for Forensic Analysis**	**(13 hours)**
2.1	Instrumental Methods: Sample preparation, calibration of instruments for accuracy and reproducibility of results in forensic analysis, method validation technique and requirements, procurement of standard samples,	
2.2	Forensic applications of TLC, HPTLC, HPLC, GC, FT-IR, AAS, GC-MS, UV-visible spectrophotometer with emphasis over standard operational procedures (SOPs) for test samples.	
2.3	Physical, Biological and Chemical Methods: Non-destructive testing probes including radiography, X-ray-radiography, Surface penetrations method (SEM and Laser Probes), Fluoroscopy,	
2.4	Clinical methods: ELISA, RIA and immune-diffusion , analysis of glucose, bilirubins, total cholesterol, creatinine, blood urea nitrogen and barbiturates in biological fluids, DNA-finger printing	
Suggested Reading Specific to the module		
2.1	Sunshine, I. Methods for Analytical Toxicology. CRC Press: USA; (1975).	

2.2	Swarbrick, J. Clarke's Isolation and Identification of Drugs, 2nd ed. Pharmaceutical Press: London; (1986).
2.3	Turner, W. Drugs & Poison (Police Evidence Library). Aqueduct: (1965).
2.4	Froede, R.C. The Laboratory Management of the Medico-Legal Specimen. Annals of Clinical & Laboratory Science, 6(3), (1976).
3.0	**Management of Toxicological Cases (14 hours)**
3.1	Introduction, Principles of Management of Poisoning Cases, Duties of a Doctor in Poisoning Cases, Signs and Symptoms of Common Poisons, Types of antidotes,
3.2	Examination and grouping of blood strains and seminal strains, Data retrieval and automation techniques for forensic examination with reference to presence of drugs, glasses, paints, oils and adhesives at crime spot.
3.3	Detection of poisoning in the Dead. Selection, Collection and Preservation of Viscera for various Types of Poisons: Choice of Preservatives, Containers and Storage
3.4	Different Methods of Extraction, Isolation, Identification, Estimation of Poisons from Biological Specimens
Suggested Reading Specific to the module	
3.1	W.J. Welcher (Ed.), Scott's Standard Methods of Chemical Analysis, Vol. III A, 6th Edition (1966), and vol. III B, 5th Edition (1975), Van Nostrand Reinhold Co. London.
3.2	Peter Fordham, Non-destructive Testing Techniques, 1st edition (1968), London Business Publications Ltd., London
3.3	W. Horwitz, Official Methods of Analysis, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.
3.4	K. Simpson and B. Knight, Forensic Medicine, 9th Edition (1985), Edward Arnold Publishers Ltd., London.
4.0	**Forensic Toxicology 13 hours**
4.1	Role of the Toxicologist, Significance of Toxicological findings, Poisons, definition, Classification on the Basis of their Origin, Physiological Action and Chemical Nature,
4.2	Analysis of various types of poisons (corrosive, irritant, analgesic, hypnotic, tranquillizer, narcotic, stimulants, paralytic, anti-histamine, domestic and industrial
4.3	Explosive and explosion residue analysis, Lethal drug analysis, Drug Abuse in Sports: Introduction, Common prohibited substances, Analytical approach. Arson: Introduction, Legal Definition
4.4	Importance of physiological tests in forensic toxicology, Analysis of Fire Scene Evidences, Instrumental Methods for Fire Debris Analysis. Analysis of Petroleum Products in Adulterant Cases

Suggested Reading Specific to the module	
4.1	Cunliffe, F. Criminalistics and Scientific Investigation (Prentice-Hall series in criminal justice).Prentice Hall: (1980).
4.2	Hodgson, E. A Textbook of Modern Toxicology 4th ed. John Wiley & Sons: Canada; (2010).
4.3	Klaassen, C. Casarett& Doll's Toxicology: The Basic Science of Poisons 8th ed. Mc Graw Hill: (2013).
4.4	Curry, A.S. Poison Detection in Human Organs. Springer:(1976).

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Curry, A.S. Advances in Forensic Chemical Toxicology. CRC Press:(1972).
2. Curry, A.S. Analytical Methods in Human Toxicology: Part II. Wiley VCH:(1986).
3. Gosselin, R.E.; Hodge, H.; Smith, R.P. and Gleason, M.N. Clinical Toxicology of Commercial Products: Acute Poisoning 4th ed. Williams & Wilkins: Baltimore; (1969).
4. Lundquist, F. and Curry, A.S. Methods of Forensic Science. Inderscience Publisher: California; (1963)
5. Maehly, A. and Stromberg, L. Chemical Criminalistics. Springer: New York; (2011).
6. Matsumura, F. Toxicology of Insecticides. Springer: New York; (1985).

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Moenssens, A.A. and Moses, R.E. Scientific Evidence in Criminal Cases. Founadation Press: New York; (1973)
2. Sharma, B.R. Forensic Science in Criminal Investigation & Trials, 6th ed. Lexis Nexis: India;(2019)
3. Stoleman, A. Progress in Chemical Toxicology. Academic Press: (2013).
4. Sunshine, I. Guidelines for Analytical Toxicology Program. CRC Press:(1950).
5. Sunshine, I. Handbook of Analytical Toxicology. CRC Press: Cleveland: (1969).

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. What is the primary goal of forensic science?
2. What is the difference between circumstantial and direct evidence?
3. Explain the use of instruments in forensic analysis
4. Discus the effect of toxicology in forensic analysis

5. Discuss the importance of physiological tests in forensic toxicology
6. Discuss the common prohibited substances in sports and their uses

Semester III	
Multi Discplinary Electice Course	
Course Code: **MSCHE03MDC01**	Course Name: **Contemporary Chemistry**

Course Description
The course is divided into four modules. Each module describes different but related concepts in contemporary chemistry. The basics of chemistry of materials, chemistry of everyday, chemistry of environment and chemistry of life are considered in the content. Different types of nanoparticles and their applications to various fields are included in chemistry of materials. The basic aspects of Issues and possible solutions of Environmental ethics, Cuase, effect and control measures are elaborately discussed in the third module. Concepts of biochemistry is encompassed in the last module.

Course Objectives	
1.	To learn the different types of materials in chemistry
2.	To study the nanomaterials chemistry
3.	To learn about the chemistry of everyday use to human
4.	To make an aware of the environmental aspects of chemistry
5.	To study the various components of medicine and food

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
4	0	4	72	0	72	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	Explain the different types of nanoparticles and their applications to various fields
C02	Comprehend the preparation, properties and applications of useful polymers
C03	Describe the properties and structure of amino acids, peptides and proteins, enzymes and drugs
C04	Explain the cause, effect and control measures of air, water and soil pollution
C05	Asses chemical components of different types of cosmetics, sensitizers, handwash, talcum powder and fresheners
C06	Describe the idea of preparation and chemistry of soaps and detergents

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of Hrs
1.0	**Chemistry of Materials 18 hrs**	
1.1	Different types of nanoparticles. Applications of nanoparticles in medicine and electronics, Quantum dots.	
1.2	Preparation, properties and applications of polyurethane, polythene, polyvinyl chloride and polyamides	
1.3	Synthetic rubbers and conducting polymers	
	Suggested Reading Specific to the module	
1.1	Nanoscale Materials in Chemistry, K.J. Klabunde, Wiley.	
1.2	Polymer Science, V.R.Gowariker; N.V. Viswanathan and J. Sreedhar, New Age	
1.3	Rubber and Plastic Technology, Mishra Chandra, CBS	
2.0	**Chemistry of Everyday 18 hrs**	
2.1	Preparation and chemistry of soaps and detergents	
2.2	General chemical components of different types of cosmetics, sensitizers, handwash, talcum powder and fresheners	
2.3	Food additives, food adulteration, carbohydrates, oils and fats	
2.4	Types of fertilizers, Bio-fertilizers	
	Suggested Reading Specific to the module	
2.1	Everyday Chemicals : In and around our homes, Gopalpur Nagendrappa, Notion Press 2022	
2.2	Wonder Chemistry : How can you relate Chemistry in your day to day life experiences, Aditi Kwatra, Notion Press	
2.3	Chemistry in Daily Life, Singh, K., Prentice Hall of India	
2.4	Chemistry of Pesticides, K.H.Buchel, John Wiley & Sons, New York, 1983	
3.0	**Chemistry of the Environment 18 hrs**	
3.1	Issues and possible solutions of Environmental ethics, Cause, effect and control measures of air, water and soil pollution, greenhouse effect	
3.2	laboratory safety precautions, Principles of green chemistry, Toxicology of nanoparticles	
3.3	Nuclear waste and its impact on the environment	
	Suggested Reading Specific to the module	
3.1	Text Book of Environmental Studies for undergraduate Courses, Bharucha Erach, University Press	
3.2	Environmental Chemistry, Day A.K, Wiley Eastern Ltd, Nanoscale Materials in Chemistry, K.J. Klabunde, Wiley.	
3.3	Nuclear Chemistry, U.N. Dash,Sultan Chand and Sons	
4.0	**Chemistry of Life 18 hrs**	
4.1	Classification, properties and structure of amino acids, peptides and proteins, Components of Nucleic acids, Nucleosides and nucleotides	

4.2	DNA, RNA and their biological functions, Enzymes, Coenzymes and cofactors and their role in biological reactions
4.3	Classification of drugs - Analgesics, Antipyretics, Antihistamines, Antacids, Antibiotics and Antifertility drugs
Suggested Reading Specific to the module	
4.1	Biochemistry, Berg, J.M., Tymoczko, J.L. & Stryer, L., W.H. Freeman
4.2	Medicinal Chemistry, D. Sriram and P. Yogeeswari, Pearson
4.3	Chemistry of Natural Products, Bhat S.V., Nagasampagi, B.A. Sivakumar M., Narosa

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Nanoscale Materials in Chemistry, K.J. Klabunde, Wiley.
2. Chemistry in Daily Life, Singh, K., Prentice Hall of India
3. Chemistry of Pesticides, K.H.Buchel, John Wiley & Sons, New York, 1983
4. Polymer Science, V.R.Gowariker; N.V. Viswanathan and J. Sreedhar, New Age
5. Text Book of Environmental Studies for undergraduate Courses, Bharucha Erach, University Press
6. Environmental Chemistry, Day A.K, Wiley Eastern Ltd
7. Nuclear Chemistry, U.N. Dash,Sultan Chand and Sons
8. Biochemistry, Berg, J.M., Tymoczko, J.L. & Stryer, L., W.H. Freeman

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Chemistry for Changing Times, J.W. Hill; T.W. McCreary and D.K. Kolb, Prentice Hall
2. Environmental Encyclopedia, Cunningham, W.P.Cooper, T.H.Gorhani, E, Hepworth, M.T. Jaico Publ. House.
3. Medicinal Chemistry, D. Sriram and P. Yogeeswari, Pearson

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Explain applications of nanoparticles in medicine
2. Discuss the preparation of soaps and detergents
3. Differentiate between Nucleosides and nucleotides?

4. Describe fertilizers and Bio-fertilizers
5. Discuss the various causes of soil pollution and its prevention methods

Semester IV	
Core Course	
Course Code: **MSCHE04DSC13**	Course Name: **Research Project**

Course Description
The aim of the course is to give the students an opportunity to perform a research project within the field of biomedicine under supervision according to an individual study plan, to summarize the results in a research report and present the results of the project

Course Objectives	
1.	Carry out a substantial research-based project
2.	Demonstrate capacity to improve student achievement, engagement and retention
3.	Demonstrate capacity to lead and manage change through collaboration with others
4.	Demonstrate an understanding of the ethical issues associated with practitioner research
5.	Analyze data and synthesize research findings
6.	Report research findings in written and verbal forms
7.	Use research findings to advance education theory and practice

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
0	12	12	0	480	480	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	apply experimental methods to solve a given scientific task,
C02	collect data for evaluation and for statistical treatment, if relevant,
C03	use relevant scientific literature
C04	perform a research project according to an individual study plan,
C05	show independence, critical and creative thinking,
C06	document results by writing a research report,
C07	present and discuss the research results with colleagues and senior researchers,
C08	formulate new scientific questions that came up during project performance

Semester IV	
Elective Course	
Course Code: **MSCHE04DSE13**	Course Name: **Inorganic and Nano Materials**

Course Description
The first part of the course describes some key topics in inorganic materials and nanomaterials. It provides a solid background for students who intend to continue with master's degree studies within inorganic, materials, and nano-chemistry. The methods of formation, properties and applications of inorganic materials such as titanium and its alloys, metallocycles, cages and clusters of elements. Oxides and sulfides of transition elements and their studies, various application oriented metals, zeolites, etc are also included. Various methods of synthesis of nanomaterials, their types and optical, magnetic and electric properties are also included. Applications of nanomaterials in medicine and electronics are also included.

Course Objectives	
1.	To understand the basic concepts of inorganic materials and their classifications
2.	To know building principles and have insight into important structure types for inorganic compounds
3.	To impart knowledge on the application and industrial relevance of inorganic materials like alloys and metal oxides
4.	To introduce the concepts of bonding in different metal oxides, borides, nitrides, carbides, borides etc
5.	To introduce the foundational knowledge of Nanoscience and technology in a broad aspects including background, concepts and misconceptions.
6.	Explain the effect of quantum confinement on the electronic structure on physical chemical and mechanical properties.
7.	To introduce various synthesis methods and make them able to choose an appropriate one depending upon the desired size and morphology
8.	To impart awareness on various characterization methods based on the phase morphological and optical characteristics of different nanomaterials

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	have a fundamental knowledge on the various aspects of inorganics and nanostructures
C02	understand the industrial relevance of inorganic materials with their possible applications
C03	learn the structural properties of various oxides borides silicides, etc
C04	understand deeply the metallurgical processes for the extraction of various metals
C05	have a board outline on the history and emergence of Nanoscience and Technology
C06	acquire knowledge of various nanomaterials in terms of quantum confinement and the impact of each type in their properties
C07	understand the concepts applicable during the synthesis and formation of nano-materials like top down and bottom up approaches, grain boundaries aggregation, etc
C08	synthesize Nanomaterials of different size and morphology by choosing appropriate methods.
C09	understand various characterization techniques for the nanostructures

Course outcomes based on revised Blooms taxonomy

Module	**Course Contents**	**No. of hrs**
1.0	**Chemistry of Inorganic materials**	**14 hrs**
1.1	Ellingham diagram, chemical and electrolytic reductions, reduction potentials, Latimer and Frost diagrams.	
1.2	Chemistry of Titanium and its alloys, heat treatment, alpha and beta alloys, aerospace and biomedical applications	
1.3	Chemistry of metallocycles, cages and clusters of elements, cryptands and calixeranes, biological significances	
1.4	Structure, varieties, properties and implications of borides, carbides, nitrides, phosphides and silicides.	
1.5	Oxides and sulfides of transition elements, multiple bonds and cluster variety of transition metals, higher boranes, carboranes and metalloboranes, Structure and technological importance of silicates, cement and ceramics	
	Suggested Reading Specific to the module	
1.1	Inorganic Materials, Duncan W. Bruce, Dermot O'Hare, Wiley	
1.2	Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas, Wiley ·	
1.3	Inorganic Materials Chemistry, Mark T. Weller, Oxford University Press	
1.4	Solid State Chemistry: An Introduction, Elaine A. Moore, Lesley E. Smart, CRC Press	
1.5	Synthesis, Properties and Mineralogy of Important Inorganic materials, Terence E. Warner, Wiley	
2.0	**Functionalized Inorganic Materials**	**13 hrs**

2.1	General principles of materials selection and design based on requirements of function, Intermetallics and metal matrix composites,
2.2	Metals for high temperature and cryogenic applications, Shape memory alloys and their applications, Radiation shielding materials, Atomic oxygen resistant materials, Space suit materials and materials for life support systems.
2.3	Zeolites and other porous materials. Microporous, mesoporous and macroporous materials and their uses.
2.4	Metal-organic frameworks (MOFs). Applications Metals and alloys relevant to aerospace applications
Suggested Reading Specific to the module	
2.1	Principles of Inorganic Materials Design, John N. Lalena, David A. Cleary, Wiley Inter-science
2.2	The Inorganic Chemistry of Materials: How to Make Things out of elements, Paul J. van der Put, Springer
2.3	Biomedical Applications of Inorganic Materials, Gareth R Williams, Royal Society of Chemistry
2.4	Inorganic Materials, Recent Advances Dhirendra Bahadur, Narosa Publishing House
3.0	**Chemistry of Nanomaterials 14 hrs**
3.1	Nanoscience an introduction, nanoparticle synthesis – top-down and bottom up Approaches, physical nanofabrication techniques (PVD, MBE, CVD etc.)
3.2	Nanomaterials and nanocomposites, surface energy, thermodynamics, phase transformations. Structure of nanomaterials:- tubes, fibers, wires, bricks and building blocks.
3.3	Nanostructure formation: lithography, self-assembly, molecular synthesis, crystal growth and polymerization
3.4	Properties of nanomaterials:- magnetic, optical, electrical and mechanical properties, superparamagnetic materials, transparent matrices, photochromic and electrochromic materials
3.5	Functional nanomaterials- Synthesis, properties and applications of organic, inorganic, hybrid nanomaterials – core-shells, nanoshells, self-assembled nanostructures, superlattices, nanoceramics
Suggested Reading Specific to the module	
3.1	Nanostructures and Nanomaterials Synthesis, Properties, and Applications, Cao, G., Imperial College Press
3.2	Nanomaterials and Nanochemistry, C. Bréchignac, P. Houdy, M. Lahmani, Springer
3.3	Chemistry of Nanomaterials: Fundamentals and Applications, Tahir Iqbal Awan, Almas Bashir, Aqsa Tehseen, Elsevier
3.4	Understanding Nanomaterials, Malkiat S. Johal, Lewis E. Johnson, CRC Press

3.5	Introduction to Nanoscience and Nanotechnology, Chattopadhyay K.K, A.N. Banerjee, Prentice Hall
4.0	**Advanced Nanomaterials 13 hrs**
4.1	Measurement of nanostructure, specific surface area, X-ray and electron diffraction, electron microscopy, UV-Visible Spectroscopy) Transmission Electron Microscopy, Dynamic Light Scattering Atomic Force Microscopy
4.2	Carbon based nano materials - Occurrence, production, purification, properties and applications of fullerene, carbon nanotube, graphene, carbon onion, nanodiamond and films,
4.3	Advanced nanomaterials: one, two and three dimensional nanostructures, Bulk nanostructured materials, Metal-based nanoparticles, Nonmetallic nanoparticles
4.4	Biomedical applications of nanomaterials, diagnosation, protean engineering, mapping of genes, drug delivery, biomimetics, 'smart materials' quantum dots
4.5	Applications of nanomaterials to optics, telecommunication, digital technology environment, catalysis, agriculture, automotives, sensors, electronics, photonics, information technology and aerospace sectors, NanoCAD,
Suggested Reading Specific to the module	
4.1	Nanomaterials: Synthesis, Characterization, and Applications, A.K. Haghi, Ajesh K. Zachariah, Nandakumar Kalarikkal, CRC Press
4.2	Fundamentals and Applications of Nanomaterials, Zhen Guo, Li Tan, A-1 Artech House
4.3	Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A. Ozin, André C. Arsenault, Ludovico Cademartiri, RSC publishing
4.4	Nanomaterials for Medical Applications, Zoraida Aguilar, Elsevier
4.5	Nanomaterials and Their Applications, Zishan Husain Khan, Springer

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Solid State Chemistry and its applications, Anthony.R. West, Wiley

2. 2d Inorganic Materials Beyond Graphene, C N R Rao, Umesh Vasudeo Waghmare, World Scientific
3. Transition metal oxides, An introduction to their electronic structure and properties, P.A. Cox, Oxford
4. Inorganic Materials Chemistry: General Concept and Research Topics, Ekambaram Sambandan, iUniverse publishers
5. Nanotechnology: basic science and emerging technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press
6. Springer Handbook of Nanomaterials, Robert Vajtai, Springer
7. The Chemistry of Nanomaterials: Synthesis, Properties and applications, C. N. R. Rao, Achim Müller, Anthony K. Cheetham, Wiley
8. Nanomaterials and Devices, Donglu Shi, Elsevier

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Inorganic Thermoelectric Materials: From Fundamental concepts to material design, Anthony V Powell, Royal society of Chemistry
2. Handbook of Inorganic Compounds, Dale L. Perry, CRC Press
3. Novel Structured Metallic and Inorganic Materials, Yuichi Setsuhara, Toshio Kamiya, Shin-ichi Yamaura, Springer
4. Inorganic Materials, 5 Volume Set, Duncan W. Bruce, Dermot O'Hare, Richard I. Walton, Wiley
5. Nanocomposite science and technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V. Braun, Wiley-VCH Verlag, Weiheim
6. Understanding Nanotechnology, Scientific American, Editors at Scientific American, Warner Books
7. Introduction to Nanotechnology, Charles P. Poole, Frank J. Owens, Wiley Inter-science
8. Nanotechnology: A Gentle Introduction to the Next Big Idea, Mark A. Ratner, Daniel Ratner, Mark Ratne, Prentice Hall

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Describe Ellingham diagram, Discuss its significance
2. Distinguish between cryptands and calixeranes
3. Compare the properties of microporous, mesoporous and macroporous materials
4. Discuss the properties and applications of shape memory alloys
5. Compare the properties of nanowires, nanotubes and nano-fibers
6. Discuss the applications of nanomaterials based on its optical properties

7 Discuss the various methods used for the characterization of nanomaterials

8 Illustrate the applications of nanomaterials in biomedical applications

Semester IV	
Elective Course	
Course Code: **MSCHE04DSE14**	Course Name: **Ceramics, Composites and Inorganic Polymers**

Course Description
This course deals with the fundamentals of ceramics, composites and inorganic polymers as well as their applications. The course is divided into four modules. The first modules discuss about the bonding, structure and properties of ceramics. The second module deals crystalline and non-crystalline ceramic materials. Third module include synthesis and applications of different types of composite materials (metal matrix composite, polymer matrix composite and ceramic matrix composite). Fourth module deals with bonding, structure, synthetic routes, characterization, and applications of different inorganic polymers (polyphosphazenes, polysiloxanes, polysilanes and organometallic polymers).

Course Objectives	
1.	To introduce the different types of ceramics and composite materials, their properties and applications.
2.	To introduce the special characteristics and fabrication methods of different classes of ceramics.
3.	To impart knowledge on structure and electrical, magnetic, optical, mechanical and thermal properties of ceramic materials.
4.	To introduce mechanical response of composite materials and to use this information in simple examples of design.
5.	To familiarize the structure, preparation, properties and applications of inorganic polymers

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Identify type of bonding present, types of crystal structure, and expected mechanical responses in a ceramic material.
C02	Acquire knowledge of properties of ceramics and their structural origin
C03	Identify the stress-strain response of ceramics and composites and know generally how these are altered by strengthening/hardening mechanisms, etc.
C04	Acquire knowledge about the properties and applications of ceramic matrix composites, polymer matrix composites and metal matrix composite
C05	Identify type of bonding, structure, chemical modifications and applications of inorganic polymers

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Ceramics -I 13 hours**	
1.1	Introduction, bonding, structure and its effects on physical properties, thermodynamics and kinetic considerations, sintering, defects of ceramics, diffusion	
1.2	Phase equilibria in ceramic systems (one component, binary and ternary systems), chemical reactions at high temperatures and processing of ceramics	
1.3	Thermal properties of ceramics, high temperature materials. Mechanical properties, creep, fatigue, crack growth, electrical conductivity	
1.4	Magnetic properties, Hysteresis curves, magnetic ceramics and their applications, optical properties, scattering, opacity	
	Suggested Reading Specific to the module	
1.1	Elements of Ceramics, F.H. Norton	
1.2	Introduction to ceramics, W.D. Kingery, H.K. Dowen and R.D. Uhlman, John Wiley.	
1.3	Fundamentals of Ceramics, M.W. Barsoum, McGraw Hill.	
1.4	Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons Inc.	
2.0	**Ceramics -II 14 hours**	
2.1	Crystalline ceramic materials: oxide, carbide, nitride, graphite and clay materials and their structures.	
2.2	Polymorphism, non-crystalline ceramic materials: structure and structural requirements for stability, mode of formation	
2.3	Silicate and nonsilicate glasses, hydrogen bonded structures, applications.	
2.4	Ceramic glasses and their applications, Introduction to bio-ceramic materials and their applications.	
	Suggested Reading Specific to the module	
2.1	Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.	
2.2	Introduction to the Principles of Ceramic Processing, J. S. Read, Wiley-Interscience	
2.3	Fundamentals of Ceramics, M.W. Barsoum, McGraw Hill.	
2.4	Material Science and Engineering, S.K. Hajra Choudhury, Indian Book Dist	
3.0	**Composites 13 hours**	
3.1	Introduction, classification of composites according to the matrix, classification of composites according to the reinforcement	
3.2	Synthesis techniques, properties and applications of ceramic matrix composites, polymer matrix composites and metal matrix composites	

3.3	Composite Strengths: dispersion and particulate strengthened composites. Fibers as reinforcements.
3.4	Composite Interfaces, Bonding Mechanisms, other Interfacial properties
Suggested Reading Specific to the module	
3.1	Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc
3.2	Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall
3.3	Advanced Composite Manufacturing - Gutowski, Wiley
3.4	Inorganic and organometallic polymers, Chandrasekhar V . Springer
4.0	**Inorganic polymers 14 hours**
4.1	Polyphosphazenes: Introduction, classification, bonding, synthetic routes, characterization, and biomedical applications
4.2	Organosilicon polymers: polysiloxane preparation, structure and applications
4.3	Synthesis and chemical modification of polysilanes, application of polysilanes as photoresists and photoinitiators
4.4	Organometallic polymers: Introduction, structure & bonding, synthetic routes, and applications.
Suggested Reading Specific to the module	
4.1	Introduction to polymers, Young and Lowell, Viva Publications
4.2	Contemporary polymer chemistry, Allcock, Lampe and Marle, Pearson education
4.3	Inorganic polymers, Mark JE, Allcock HR, West R. Oxford University Press, New York
4.4	Inorganic and organometallic polymers, Chandrasekhar V . Springer.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Introduction to Materials Science and Engineering, William J Callister, John Wiley & Sons, Inc.
2. Elements of Ceramics, F.H. Norton.
3. Fundamentals of Ceramics, M.W. Barsoum, McGraw Hill.
4. Introduction to ceramics, W.D. Kingery, H.K. Dowen and R.D. Uhlman, John Wiley.
5. Material Science and Engineering, S.K. Hajra Choudhury, Indian Book Dist
6. Composite Materials: Engineering and Science - F. L. Matthews and R. D. Rawlings, Chapman & Hall.
7. Advanced Composite Manufacturing - Gutowski, Wiley.
8. Inorganic polymers, Mark JE, Allcock HR, West R. Oxford University Press, New York
9. Inorganic and organometallic polymers, Chandrasekhar V . Springer.

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Polymer composites, M.C. Gupta and A.P. Gupta, New Age International
2. Introduction to polymers, Young and Lowell, Viva Publications
3. Advanced Polymer Chemistry, Chanda, Manas, CRC.
4. Contemporary polymer chemistry, Allcock, Lampe and Marle, Pearson education
5. Ceramic Materials for Electronics, R. C. Buchanan (ed.), Marcel Dekker.
6. Introduction to the Principles of Ceramic Processing, J. S. Read, Wiley-Interscience. Physics and Chemistry of Surfaces by Adamson

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. Explain Ferromagnetic ceramics with suitable hysteresis curves.
2. Write short notes on Perovskite structure and Corundum structure with examples
3. Explain the phase equilibria in one component, binary and ternary ceramic systems
4. Discuss about the applications of polysilanes as photoresistors and photoinhibitors.
5. Explain the hot-pressing method used for the production of whisker reinforced composites.

Semester IV	
Elective Course	
Course Code: **MSCHE04DSE15**	Course Name: **Advanced Organic Synthesis**

Course Description
The Course is an outlook to the latest trends in organic synthesis with applications to the technology importance. The different types of reagents for organic reactions suitable for electronic, photonics and other applications, their synthesis, design and applications are also added. Stereo, regio and specific selective organic synthesis are also included

Course Objectives
1. To learn the new synthetic methods of organic chemistry
2. To know about the latest reagents used in organic synthesis
3. To study the various types of coupling reaction

4.	To learn advanced reactions mechanisms in organic chemistry
5.	To illustrate modern methods of organic synthesis

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to

C01	learn the methodology different types of coupling reactions based on copper, palladium and other metals
C02	explain the reaction mechanisms of various coupling reactions
C03	study the methods of synthesis of ring compounds
C04	apply different reactions for the construction of heterocyclic compounds.
C05	explain the synthesis of organic compounds with specified stereochemistry
C06	Lear the properties of modern organic molecules with their applications in technology fields.

Course outcomes based on revised Blooms taxonomy

Module	Course Contents
1.0	**Modern Organic Synthetic Methods 14 hrs**
1.1	Coupling reactions, homo and cross coupling reactions, Mechanism, importances and applications of Glaser coupling and Gomberg-Bachmann reaction.
1.2	Mechanism and applications of copper catalyzed cross coupling reactions, Cadiot-Chodkiewicz coupling, Castro-Stephens coupling and Corey-House synthesis
1.3	Cross coupling reactions based on palladium, Hiyama coupling, Buchwald-Hartwig reaction and Liebeskind–Srogl coupling
1.4	Coupling reactions based on palladium coupled with other metals, Cross dehydrogenative coupling, Fukuyama coupling, Murahashi coupling and Kumada coupling
Suggested Reading Specific to the module	
1.1	Organic Synthesis Strategy and Control, Paul Wyatt and Stuert Warren, John Wiley
1.2	Organic Synthesis using Transition Metals, Roderick Bates, Wiley, 2012
1.3	A Theoretical Study Of Pd-catalyzed C-c Cross-coupling reactions, Max Garcia Melchor, Springer Thesis

1.4	Catalyst Components for Coupling Reactions, Molander Gary A,Wiley
2.0	**Construction of Ring Systems 13 hrs**
2.1	Different approaches towards the synthesis of three, four, five, and six-membered rings. Baldwin's Rule for Ring Closure Reactions, Danheiser annulation, Robinson annulation
2.2	Construction of heterocyclic ring compounds, Bischler–Napieralski reaction, Azide-alkyne Huisgen cycloaddition, Feist–Benary synthesis, Toggle the table of contents Gewald reaction
2.3	Additions involving cyclic intermediates, cyclopropanation, Carbene reactions, nitrene and benzyne reactions, epoxy formation
2.4	Construction of macrocyclic rings and ring closing metathesis, Sammes Annulation
Suggested Reading Specific to the module	
2.1	Small Ring Compounds in Organic Synthesis VI, Armin de Meijere, Wiley
2.2	Modern Organic Synthesis: An Introduction, George S. Zweifel and Michael H. Nantz, W. H. Freeman Publisher, 2007
2.3	Transition-Metal-Mediated Aromatic Ring Construction, Ken Tanaka, Wiley
2.4	Organic Chemistry: Structure and Function, Vollhardt, K. Peter C. and Schore, Neil E.. New York: Bleyer, Brennan, 2007.
3.0	**Asymmetric Organic synthesis 14 hrs**
3.1	Metal catalyzed asymmetric enantioselective oxidation, reduction, C-C bond forming reactions, allylic substitution, cyclization, and other important reactions.
3.2	Chiral organo-catalysts including phase transfer catalysts and hydrogen bonding catalysts, and supported chiral catalysts. Kinetic resolution, parallel kinetic resolution, dynamic kinetic resolution and dynamic thermodynamic resolution.
3.3	Chiral poisoning, chiral activation, desymmetrization, nonlinear effect, autocatalysis, auto induction, double diastereo-selection and remote chiral induction in asymmetric synthesis.
3.4	Determination of optical purity using NMR, GC and HPLC techniques including principles, determination of absolute configuration by NMR and X-Ray crystallography
Suggested Reading Specific to the module	
3.1	Stereoselectivity in organic synthesis, G. Procter, Oxford Chemistry Primers, 2007.
3.2	Domino Reactions in Organic Synthesis, L. F. Tietze, G. Brasche, and K. Gericke, Wiley, 2006
3.3	Fundamentals of asymmetric catalysis, P.J.Walsh and M.C. Kozlowski, University science books, USA, 2009.
3.4	Catalytic Asymmetric Synthesis, 3rd ed, Ed: I. Ojima, John Wiley & Sons, New Jersey, 2010.

4.0	**Functional Organic Materials 13 hrs**
4.1	Organic Electronic Materials: Theory of electronics, design of molecular wires, Diodes and OLEDs - Introduction to various device configurations and working principles, synthesis of organic molecules
4.2	Organic Photonic Materials: Theory of photonics, design of molecules for Organic solar cells – Various types of organic molecules used, device aspects, Molecules for NLO and imaging – Molecular switches, Motors and Memories – synthesis of organic molecules
4.3	Organic Energy Materials: Basic theory, design of Organic Flow Batteries for Energy Storage applications, High energy materials, Covalent Organic Frameworks, requirements of organic molecules and their synthesis
4.4	Organic Molecular Machines: Introduction, types, design, functions, fabrication of devices synthesis, and examples
Suggested Reading Specific to the module	
4.1	OLED Fundamentals: Materials, Devices, and Processing of organic light emitting diodes, Daniel J. Gaspar, Evgueni Polikarpov, CRC press
4.2	Materials Concepts for Solar Cells, Thomas Dittrich, World Scientific Publishing UK Limited
4.3	Emerging Materials for Energy Conversion and Storage, Kuan Yew Cheong, Giuliana Impellizzeri, Mariana Amorim Fraga, Elsevier
4.4	Advanced Functional Materials, Hee-Gweon Woo, Hong, Springer

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Strategic Applications of named Reactions in Organic Synthesis, L. Kuerti and B. Czako, Elsevier Academic Press, 2005

2 Carbene Formation by Extrusion of Nitrogen, Abdel-Wahab, Aboel-Magd A. Ahmed, Saleh A. and Dürr, Heinz, CRC Handbook of Organic Photochemistry and Photobiology. CRC Press, 2004

3 Organic Chemistry- Principles and Mechanisms, Karty, J, W. W. Norton, 2014

4 Designing Organic Synthesis, S. Warren, John Wiley, 1978

5 Asymmetric Synthesis – The Essentials, Eds.: M. Christmann and S. Brase, Wiley-VCH Verlag GmbH, Weinheim, 2007

6 Comprehensive Asymmetric Catalysis I-III; Editors: Eric N. Jacobsen, Andreas Pfaltz, Hisashi Yamamoto; Springer-Verlag Berlin Heidelberg, Germany, 1999

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Advanced Organic Chemistry, Part A and B, F. A. Carey and R. I. Sundberg, Plenum Press

2. Principles and Applications of Organotransition Metal Chemistry, J. P. Collman, L. S. Hegedus, J. R. Norton, and R. G. Finke, University Science Books

3. Organic Synthesis, Michael B. Smith, McGraw Hill

4. Polar rearrangements, L. M. Harwood, Oxford University Press
5. Guidebook to Organic Synthesis, R. K. Mackie and D. M. Smith, ELBS.
6. Organotransition Metal Chemistry, Application to Organic Synthesis, S. G. Davies, Pergamon Press.

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1. Discuss the applications of copper catalyzed cross coupling reactions
2. Explain the mechanism of Murahashi coupling
3. Explain the Baldwin's Rule for Ring Closure Reactions
4. Discuss the mechanism of Gewald reaction
5. Discuss parallel kinetic resolution
6. Explain the methods of determination of asymmetric purity
7 Describe the device fabrication of OLED
8 Discuss the theory of organic solar cells

Semester IV	
Elective Course	
Course Code: **MSCHE04DSE16**	Course Name: **Green and Sustainable Chemistry**

Course Description
Green chemistry is the utilization of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. This course will focus on the development of green chemistry, definitions and metrics, prevention of pollution at source through new/sustainable synthetic methods. The course will also focus on few examples of commercial applications of green chemistry.

Course Objectives
4. To develop and demonstrate knowledge pertaining to the background and development of green chemistry
5. To understand the common metrics used in green chemistry applications.

6.	To learn introductory green chemical synthetic methods, choice of solvents, atom economy, and sustainable raw materials
7.	To understand and explain selected real-world examples of green chemistry

Credit			Teaching Hours			Assessment		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Apply the principles of green chemistry to chemical-related problems and waste reduction.
C02	Apply the principles of green chemistry to improve chemical manufacturing processes
C03	Acquire knowledge on applications of non-conventional energy sources for green synthesis
C04	Acquire knowledge on environmentally benign solvents and sustainable raw materials used in green chemistry
C05	Rationalize the existing chemical processes, assess their sustainability and propose more sustainable amendments or commercially viable alternatives

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Introduction to green chemistry**	**14 hrs**
1.1	Introduction, principle and concepts of green chemistry	
1.2	Need for green chemistry, inception and evolution of green chemistry	
1.3	Twelve principles of green chemistry with their explanations and examples Designing a green synthesis using these principles.	
1.4	Green chemistry in day to day life	
Suggested Reading Specific to the module		
1.1	Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press, Oxford; 1998. ISBN: 0-19-850234-6	
1.2	Baird, C.; Cann, M. Environmental Chemistry, Fifth Edition; W. H. Freeman and Company, New York; 2012. ISBN-13: 978-1-4292-7704-4. (Toxicology, Chapters 13-15)	
1.3	Manahan, S. E. Environmental Chemistry, Eighth Edition; CRC Press, 2005. ISBN: 1-56670-633-5. (Toxicology, Chapters 22-23)	

1.4	Lancaster, M. Green Chemistry: An Introductory Text, Third Edition; RSC Publishing; 2016. ISBN: 978-1-78262-294-9
2.0	**Different approaches to green synthesis 13 hrs**
2.1	Uses of green reagents in organic synthesis - Dimethyl carbonate, polymer supported reagents peracids and chromic acid
2.2	Green catalysts, role of catalysis in sustainable development, homogeneous and heterogeneous catalysts
2.3	Introduction, advantages and applications of nanocatalysts and phase transfer catalysts
2.4	Biocatalysts, advantages and applications of organocatalysts in organic synthesis
Suggested Reading Specific to the module	
2.1	P.T. Anastas, J.C. Warner, Green Chemistry, theory and practice, Oxford University Press.
2.2	Lancaster, M. Green Chemistry: An Introductory Text, Third Edition; RSC Publishing; 2016. ISBN: 978-1-78262-294-9
2.3	V. Polshettiwar, T. Asefa, G. Hutchings, Nanocatalysis: Synthesis and applications, Wiley.
2.4	M. Lancaster, Green Chemistry: An introductory text, Royal Society of Chemistry.
3.0	**Applications of non-conventional energy sources 14 hours**
3.1	Introduction of microwave induced synthesis: Microwave activation, equipment, time and energy benefits, limitations.
3.2	Organic transformations under microwaves: Fries rearrangement, Diels-Alder reaction, decarboxylation, saponification of ester, alkylation of reactive methylene compounds
3.3	Introduction of ultrasound assisted green synthesis: Instrumentation, physical aspects, applications in organic transformations
3.4	Electrochemical synthesis: Introduction, synthesis of sebacic acid and adiponitrile.
Suggested Reading Specific to the module	
3.1	M.A. Ryan, M. Tinnesand, Introduction to Green Chemistry, American Chemical Society.
3.2	P.T. Anastas, Handbook of Green Chemistry, John Wiley and Sons.
3.3	V.K. Ahluwalia, MKidwai, New Trends in Green Chemistry, Springer.
3.4	Paul T Anastas, Innovations in Green Chemistry and Green Engineering, Springer.
4.0	**Green Solvents and Renewable Resources 13 hours**
4.1	Ionic liquids as green solvents: Introduction, properties and types of ionic liquids. Aqueous phase reactions: Enhancement of selectivity, efficiency.
4.2	Role of supercritical carbon dioxide in green chemistry. Fluorous solvents in

	green chemistry: Scope, definition and their synthetic applicability.
4.3	Green chemistry in material science, synthesis of porous polymers, green nanotechnology.
4.4	Biomass as a renewable resource of energy. Chemicals and polymers from renewable feedstock.
Suggested Reading Specific to the module	
4.1	Green Chemistry, Mike Lancaster, The Royal Society of Chemistry, Cambridge, UK, 2002.
4.2	Introduction to Green Chemistry, Albert S. Matlack, Marcel Dekker, Inc., New York, 2001.
4.3	Green Chemistry: Environmentally Benign Reactions, V. K. Ahluwalia, Ane Books India, New Delhi, 2006
4.4	Green Chemistry: Frontiers in benign chemical synthesis and processes, Paul T. Anastas and Tracy C. Williamson (Eds.), Oxford University Press, Oxford, 1998.

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Chemical Synthesis using Supercritical fluids, P. G. Jessop and W. Leitner (Eds.), Wiley – VCH, Verlag, Weinheim, 1999.
2. Solvent Free Organic Synthesis, Koichi Tanaka, Wiley – VCH GmbH and Co. KgaA, Weinheim, 2003.
3. Green Chemistry, Theory and Practice, P. T. Anastas and J. C. Warner, Oxford University Press, N. York, 1998
4. Organic Reactions in aqueous Media, C - Jun Li and T – Hang Chan, John Wiley and Sons INC., N. York, 2001.
5. Organic Synthesis on Solid Phase, F. Z. Dorwald, Wiley – VCH Verlag, Weinheim, 2002.
6. Ionic Liquids in Synthesis, Peter Wasserscheid and Tom Welton (Eds.), Wiley – VCH Verlag, Weinheim, 2003.
7. Microwaves in Organic Synthesis, Andre Loupy (Ed.), Wiley – VCH Verlag, Weinheim, 2002.
8. Alternative Solvents for Green Chemistry. F.M. Kerton. Royal Society of Chemistry (London).

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

4. Green Chemistry: Theory and Practice. P.T. Anastas and J.C. Warner. Oxford University Press.
5. Green Chemistry: Introductory Text. M. Lancaster Royal Society of Chemistry (London).
6. Introduction to Green Chemistry. M.A. Ryan and M.Tinnesand, American Chemical Society (Washington).

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1. What are the twelve green chemistry principles?
2. Discuss the role of supercritical carbon dioxide in green chemistry.
3. Write a short note on different types of ionic liquids.
4. Explain the ultrasound-assisted green synthesis.
5. Write a short note on green catalysts.

Semester IV	
Elective Course	
Course Code: **MSCHE04DSE17**	Course Name: **Advanced Nanomaterial Synthesis**

Course Description
This course focuses on different methods used for the synthesis of nanomaterials. The course is divided into four modules. In the first module, different physical methods used for the synthesis of nanomaterials are discussed. The second module deals with different chemical methods and the third one discusses about the biological methods for synthesis of nanomaterials. The module deals with lithographic techniques

Course Objectives	
1.	To learn the top-down and bottom-up synthesis approach of nanomaterials.
2.	To understand various physical, chemical and biological methods for the synthesis of nanomaterials.
3.	To tune the morphology and functional properties of nanomaterials by tuning the reaction parameters.
4.	To apply basic knowledge of synthesis to prepare functional and smart nanomaterials.
5.	To understand the lithographic process for the fabrication of micro and nanodevices

Credit			**Teaching Hours**			**Assessment**		
L/T	**P/I**	**Total**	**L/T**	**P/I**	**Total**	**CE**	**ESE**	**Total**
3	0	3	54	0	54	40	60	100

L/T: Lecture/ Tutorial; P/I: Practical/Internship; CE: Continuous Evaluation, ESE: End Semester Evaluation

COURSE OUTCOMES

Course Learning Outcomes: At the end of the course, the student will be able to –

C01	Synthesize nanomaterials using physical, chemical and biological approaches.
C02	Predict the nucleation and growth mechanisms of various nanostructures
C03	Tune the size and shape of the nanomaterials for diverse applications.
C04	Understand the functionalization of nanoparticles for specific applications
C05	Form the nanocomposites for tuning their functional properties.
C06	Fabricate the device structures using lithographic techniques

Course outcomes based on revised Blooms taxonomy

Module	Course Contents	No. of hrs
1.0	**Physical methods for synthesis of nanomaterials**	**14 hrs**
1.1	Inert gas condensation-Principle, advantages and disadvantages, arc discharge – synthesis of CNTs and fullerenes, laser ablation-principle, Coloumb explosion	
1.2	Laser pyrolysis- Principle, advantages and disadvantages, layer deposition, ball milling-principle, grinding media, Spray pyrolysis,	
1.3	Ion implantation, Physical Vapour deposition - Principle, evaporation and sputtering, molecular beam epitaxy	
1.4	Chemical vapour deposition method- homogeneous and heterogeneous process, transport phenomenon, reaction kinetics, types of CVD, Electrospinning processing parameters, factors affecting the process	
	Suggested Reading Specific to the module	
1.1	Applications by Guozhong Cao, Imperial college Press, (2006). Publisher: World Scientific Publishing Company;	
1.2	Introduction to Nanoscience and Nanotechnology, Chattopadhyay K.K, Prentice Hall India Learning Private Limited	
1.3	An introduction to Electrospinning and Nanofibersj Seeram Ramakrishna, Kazutoshi Fujihara, Wee Eong Tee, Teck Cheng Lim, Zaveri Ma, World Sci. Pub. Ltd. Singapore, 2005.	
1.4	Springer Handbook of Nanotechnology - Bharat Bhusan Publisher: Springer-Verlag (2006)	
2.0	**Chemical methods for synthesis of nanomaterials**	**13 hrs**
2.1	Chemical methodologies, their advantages, nanoparticles, 1D-nanostructures-Nanowires, nanotubes and nanorods, Nanoparticles through homogeneous & heterogenous nucleation in solution	
2.2	Co-precipitation, chemical reduction, hydrothermal synthesis- isothermal and temperature gradient methods, Solvothermal synthesis	
2.3	Template based synthesis, Electrochemical synthesis, Sonochemical synthesis-cavitation, Polyol method, Sol-gel synthesis- reactions and catalysts,	
2.4	Micelles and Microemulsion assisted synthesis- principle and parameters that	

	affect size and shape of nanostructured products, Thermal decomposition, Langmuir Blodgett (LB) method.
Suggested Reading Specific to the module	
2.1	Nanoscience and Nanotechnology: Fundamentals of Frontiers, Shubra Singh M.S. Ramachandra Rao, Wiley
2.2	Fabrication And Application Of Nanomaterials, S Bandhopad Hyay, McGraw Hill.
2.3	Nanomaterials: Mechanics And Mechanisms, Ramesh K.T Springer (India) Pvt. Ltd.
2.4	Nanomaterials And Nanocomposite : Synthesis Properties Characterization Techniques And Applications, Rajendra Kumar Goyal, T&F India
3.0	**Biological methods for synthesis of nanomaterials 14 hrs**
3.1	Use of bacteria, fungi, actinomycetes and algae for nanoparticle synthesis, natural synthesis of magnetic nanoparticles using magnetotactic bacteria – magnetosomes,
3.2	Viruses as components for the formation of nanostructured materials – common virus types used, scaffolds, specific features of plant viruses, functionalizing scaffolds
3.3	Role of plant derivatives in nanoparticle synthesis. Nanoparticle synthesis with the help of enzymes- biocatalystic enlargement,
3.4	Cofactor-assisted Nanoparticle synthesis, DNA-assisted synthesis of nanoparticles, Nanomaterial synthesis from industrial or agricultural wastes-
Suggested Reading Specific to the module	
3.1	An Introduction to Nanomaterials and Nanoscience, Asim K Das and Mahua Das, CBS Publication
3.2	Nanotechnology: An introduction to synthesis, properties and applications of nanomaterials, Thomas Varghese, K.M. Balakrishna, Atlantic Publishers and Distributors
3.3	Nanostructure and Nanomaterials, Parthasarathy B.K. Isha Books
3.4	Advances in Nanomaterials and Composites, Ravindra Singh Rana. Rajesh Purohit Priyanka Verma, Saraswati Rana, Deepen Banoriya, Walnut Publication
4.0	**Lithographic techniques for fabrication of nanomaterials 13 hrs**
4.1	Basics of micro and nano lithography processes, Optical Lithography- Proximity, contact and projection printing, Materials and methods
4.2	Electron beam lithography- Rastor scan and vector scan, Pros and cons, proximity effects,
4.3	X-ray lithography- processes, advantages and disadvantages, geometric effects, Focused ion beam lithography, Near field Scanning
4.4	AFM lithography – Bias assisted and force assisted methods, Dip pen lithography- Diffusive and Liquid Inks,

Suggested Reading Specific to the module	
4.1	A Textbook Of Nanoscience, Rakesh Kumar & Kamala Pati Tiwary, S.K. Kataria & Sons
4.2	Textbook of nanosciene and nanotechnology, Murthy Raj, Shankar Rath Murd, Orient Blackswan Private Limited
4.3	Springer Handbook of Nanotechnology - Bharat Bhusan Publisher: Springer-Verlag (2006)
4.4	Introduction to Nanoscience & Nanotechnology, Gabor L. Hornyak, Harry F. Tibbals,Joydeep Dutta, John J. Moore, CRC Press,

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks) List

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications, Guozhong Cao , Imperial college Press, (2006).
2. An introduction to Electrospinning and Nanofibers, Seeram Ramakrishna, Kazutoshi Fujihara, Wee Eong Tee, Teck Cheng Lim, Zaveri Ma, World Sci. Pub. Ltd. Singapore, 2005.
3. Springer Handbook of Nanotechnology - Bharat Bhusan Publisher: Springer-Verlag (2006)
4. Introduction to Nanoscience & Nanotechnology, Gabor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press,
5. Introduction to Nanoscale Science & Technology, Di Ventra, Evoy, Heflin, Springer Science, NY, 2004. Publisher: Springer; 1 Edition (2004)
6. Nanofabrication- Fundamentals and Applications, Ampere A Tseng, Singapore 2008. Publisher: World Scientific Publishing Co Pte Ltd

Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks) List

1 Nanoparticles and Nanostructured Films- Preparation Characterization and Applications, Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim

2 Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens, Publisher: Wiley-Interscience;

3 Nanomaterials Theory Problems and Solutions, Upendranath Nandi, Debnarayan Jana, echno World; 2nd Edition (2020)

4 Nanomaterials Synthesis Properties and Applications, Nitin K Puri, I K International Publishing House Pvt Ltd

Teaching Learning Strategies

- Assignments, Internal examinations, Seminars, Semester Viva Voce

Mode of Transaction

- Off-line mode, Black Board and Chalk

ASSESSMENT RUBRICS

	Marks

End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes

1 Explain the synthesis of nanomaterials by physical vapour deposition method.

2 Write a short note on sonochemical synthesis of nanomaterials.

3 Discuss the synthesis of nanomaterials by sol-gel technique.

4 Explain DNA-assisted synthesis of nanoparticles.

5 Write a short note on near field scanning optical lithography