SYLLABUS

JOINT MASTERS PROGRAMME IN CHEMISTRY (NANOSCIENCE AND NANOTECHNOLOGY)

Between

SCHOOL OF NANOSCIENCE AND NANOTECHNOLOGY,

MAHATMA GANDHI UNIVERSITY, KOTTAYAM, KERALA

AND

DEPARTMENT OF CHEMISTRY, KANNUR UNIVERSITY,

SWAMI ANANTHATHEERTHA CAMPUS, PAYYANUR, KANNUR

PREFACE

We are happy to present the curricula and syllabi of the following Joint M.Sc. Chemistry (Nanoscience and Nanotechnology) Programme according to the OBE concept for favour of approval by the Faculty and Academic Council of the University. The Board of Studies has developed the curriculum as per the Outcome Based Education (OBE) system. OBE is an educational approach that bases each part of the educational system with respect to the goals set for the students. OBE aims to equip the students (learners)with knowledge, competency orientations required for achieving their goals when they depart the institution. Further OBE empowers students to choose what they would like to study and how they would like to study it. The teaching methodologies and the evaluation system are also modified in par with the outcome-based approach. The Programme Specific Outcomes (PSOs) and the Course Outcomes (COs) for joint M.Sc. are presented in the syllabus. The PSOs and the COs are well correlated in the syllabus of each course.

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EXPERT COMMITTEE

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Convenor Dr. Sreekala M.S, Associate Professor, SCS Joint Director, School of Nanoscience and Nanotechnology	**Convenor** Dr. Sudheesh S., Professor & Head, School of Chemical Sciences
Prof. (Dr.) Nandakumar Kalarikkal, School of Pure and Applied Physics	Dr. Baiju K.V, Asssistant professor, School of Chemical Sciences
Prof. (Dr.) C. Sudarsana Kumar, School of Pure and Applied Physics	Dr. Nissamudeen K.M., HoD, School of Pure and Applied Physics
Prof. (Dr.) Suresh Mathew, School of Chemical Sciences	Dr. Deepak N.K, Associate Professor, School of Pure and Applied Physics
	Dr. Shima P Damodaran, Assistant Professor, School of Chemical Sciences

External Experts

Dr. Kuruvila Joseph, Professor, IIST, Thiruvananthapuram.
Dr. Hareesh, Principal Scientist, NIIST, Thiruvananthapuram.

Programme Outcomes (PO) of Joint M.Sc. Programme

PO 1: Critical Thinking and Analytical Reasoning Capability to analyse, evaluate and interpret evidence, arguments, claims, beliefs on the basis of empirical evidence; reflect relevant implications to the reality; formulate logical arguments; critically evaluate practices, policies and theories to develop knowledge and understanding; able to envisage the reflective thought to the implication on the society.

PO 2: Scientific Reasoning and Problem-Solving Ability to analyse, discuss, interpret and draw conclusions from quantitative/qualitative data and experimental evidences; and critically evaluate ideas, evidence and experiences from an unprejudiced and reasoned perspective; capacity to extrapolate from what one has learned and apply their competencies to solve problems and contextualise into research and apply one's learning to real life situations.

PO 3: Multidisciplinary/Interdisciplinary/Transdisciplinary Approach Acquire interdisciplinary/ multidisciplinary/transdisciplinary knowledge base as a consequence of the learning they engage with their programme of study; develop a collaborative- multidisciplinary/ interdisciplinary/transdisciplinary-approach for formulate constructive arguments and rational analysis for achieving common goals and objectives.

PO 4: Communication Skills Ability to reflect and express thoughts and ideas effectively in verbal and nonverbal way; Communicate with others using appropriate channel; confidently share one's views and express herself/himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner and articulate in a specific context of communication.

PO 5: Leadership Skills Ability to work effectively and lead respectfully with diverse teams; setting direction, formulating a goal, building a team who can help achieve the goal, motivating and inspiring team members to engage with that goal, and using management skills to guide people to the right destination, in a smooth and efficient way.

PO 6: Social Consciousness and Responsibility Ability to contemplate of the impact of research findings on conventional practices, and a clear understanding of responsibility towards societal needs and reaching the targets for 12 attaining inclusive and sustainable development.

PO 7: Equity, Inclusiveness and Sustainability Appreciate equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity,

secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity, managing diversity and use of an inclusive approach to the extent possible.

PO 8: Moral and Ethical Reasoning Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work and living as a dignified person in the society.

PO 9: Networking and Collaboration Acquire skills to be able to collaborate and network with scholars in an educational institution, professional organizations, research organizations and individuals in India and abroad.

PO 10: Lifelong Learning Ability to acquire knowledge and skills, including "learning how to learn", that are necessary for participating in learning activities throughout life, through self- paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling.

PROGRAMME	: Joint M. Sc. Chemistry (Nanoscience and Nanotechnology)
DURATION	: 2 years (2022 Admission onwards)
Total credits	: 87 (for 4 semesters) [Core:71; Elective: 12; Open: 4]

**The *student has to choose two elective courses for semester I, two elective courses for semester II and two elective courses for semester III.

**The student has to choose one open course of 4 credits for semester III from any other School under the Faculty of Science.

*** In the evaluation process internal –Continuous Assessment (CA) - accounts for 40% and the End- Semester Examination will account for the remaining 60%.

Program Specific Outcomes:(PSOs): At the completion of the M.Sc. Nanoscience and Nanotechnology (Chemistry) program, the students from school of Nanoscience and Nanotechnology will be able to:

PSO	Programme Specific Outcome	MGU & KU PO No.
1	Provide a strong foundation in Chemistry that emphasizes scientific reasoning and analytical problem solving.	1,3
2	Provide students with the skills required to succeed in M.Sc., also enrich the students with a basic skill to perform in Chemical industry especially in the field of Nanoscience and Nanotechnology.	1,2,6
3	Promote research interest in students and enable them towards planning and execution of research in frontier areas of chemical sciences.	3,8
4	Expose the students to a level of experimental techniques using modern instrumentation.	1,2
5	Demonstrate teamwork, communication, Time management and leadership skills across multicultural contexts.	4,5,7,9
6	Acquire the ability to synthesize and characterize compounds using sophisticated instrumental techniques and related soft-wares, for the in-depth characterization of nano materials	1,2
7	Develop solid knowledge, understanding and expertise in the domain of Nanoscience and Nanotechnology.	1,2,10
8	Inspire the students to be committed to deliver good to the society by judicious application of scientific skill sets they acquire doing Chemistry at the nanoscale.	3,7,8,9
9	Nurture the quality of rationality and inquisitiveness, so that the students are capable of free and critical thinking to steer clear judgmental and social biases.	2,4,5,9

SEMESTER	COURSE CODE	NAME OF THE COURSE	CREDIT	TOTAL CREDIT
I (MG University + Kannur University)	**CORE**			24
	MGKUMPNSC30	Coordination Chemistry	4	
	MGKUMPNSC31	Structural and Molecular Organic Chemistry	3	
	MGKUMPNSC32	Quantum Chemistry and Group Theory	3	
	MGKUMPNSC33	Physical Chemistry I	3	
	MGKUMPNSC34	Introduction to Nanomaterials	3	
	MGKUMPNSC35	Practical I - Organic Chemistry	2	
	MGKUMPNSC36	Practical II - Inorganic Chemistry	2	
	ELECTIVE (Choose any one)			
	MGKUMPNSE12	Surface Chemistry and Catalysis	4	
	MGKUMPNSE13	Nanocomposites	4	
II (Kannur University)	**CORE**			24
	MGKUMPNSC37	Organometallics and Bioinorganic Chemistry	4	
	MGKUMPNSC38	Organic Reaction Mechanisms	3	
	MGKUMPNSC39	Spectroscopic Methods in Chemistry	4	
	MGKUMPNSC40	Nanomaterials and Characterization	3	
	MGKUMPNSC41	Practical III - Organic Chemistry	2	
	MGKUMPNSC42	Practical IV - Physical Chemistry	2	
	ELECTIVE (Choose any one)			
	MGKUMPNSE14	Chemical Bonding and Computational Chemistry	4	
	MGKUMPNSE15	Nanoelectronics and Electrochemistry	4	
	MGKUMPNSC43	**INDUSTRIAL INTERNSHIP**	2	
III (MG University)	**CORE**			23
	MGKUMPNSC44	Advanced Synthetic Organic Chemistry	4	
	MGKUMPNSC45	Physical Chemistry - II	4	
	MGKUMPNSC46	Application of Nanomaterials	3	
	MGKUMPNSC47	Practical V - Synthesis of Nanomaterials	2	
	MGKUMPNSC48	Practical VI - Characterization of Nanomaterials	2	
	ELECTIVE (Choose any one)			
	MGKUMPNSE16	Chemistry of Natural Products and Biomolecules	4	
	MGKUMPNSE17	Nanomedicine and Drug Delivery System	4	
		OPEN COURSE	4	
IV (Project)	MGKUMPNSC49	Dissertation	12	16
	MGKUMPNSC50	Viva-Voce	4	
TOTAL PROGRAMME CREDITS				**87**

SEMESTER I

Programme	**Joint M.Sc.**
Course Name	**Coordination Chemistry**
Type of Course	**Core**
Credit Value	**4**
Course Code	MGKUMPNSC30

Course Summary & Justification	Main group elements, the most abundant elements in the universe were among the first developed in the modern era for diverse inter-disciplinary applications. The study of Main Group Chemistry unravels the basic composition, structures, and properties of elements. Through this learning, it is possible to acquire relevant conceptual and procedural knowledge, to develop understanding and appreciation of developments in various scientific and technological fields. The course also aims to help the students to detail out the bonding, structures and properties of coordination complexes. The description of various bonding theories with emphasizes on the spectral and magnetic properties of coordination complexes helps to predict the characteristic properties of any transition metal complex. Different reactions in transition metal complex with a supportive mechanism will be discussed. The applications of coordination chemistry in various field will also be described at the conclusion part to understand importance of learning this course					
Semester	I					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		60	40	0	40	140
Pre-requisite	Basic knowledge about periodic table and arrangements of elements under Groups and Periods. Basic knowledge in Inorganic Chemistry					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the classification of elements in the periodic table: general trends and properties of elements and structure of molecules	U	1,5
2	Understand the Chemistry of group III elements and apply Wade's rule and STYX number in rationalizing the structure of main group clusters	U, A	1,5
3	Understand about the diversity of oxides, sulfides, halides and hydrides of group IV, V and VI elements	U, R	1,5
4	To understand the structure and bonding of coordination complex	U	1,5
5	To predict the shape of coordination complexes using VBT & CFT	U	1,5
6	To estimate the CFSE of any complex and predicts low spin/high spin nature	U, A	1,5
7	To study spectral and magnetic properties of coordination complexes	U, An	1,5
8	Should be able to derive the term symbol for any electronic configuration	U, A, An	1,5
9	Should be able to draw Orgel diagrams and recognise the electronic transition in the spectra of any coordination complexes	U, A	1,5
10	To be able to describe the stability of coordination complexes by the use of formation constants and to calculate thermodynamic parameters from them	U, A	1,5
11	To predict the products formed after electron transfer reaction between two coordination complexes	U	1,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Chemistry of Main group Elements** General trends in the properties of the elements, Occurrence and extraction; Group I and II elements and their compounds, Chemistry of group III elements: Inorganic chains, rings and cages; Boranes, Boron halides, Diborane, Borazines, Borates, Boron clusters, Higher boranes and borohydrides, Organoboranes: carboranes and metallocarboranes, STYX numbers and WADE's rule,Isolobal concept: molecular geometry and molecular symmetry,Main group clusters: Cyclic and crown ethers, Silicon-oxygen compounds, Silicates, Silicons, Zeolites, Silanes, Silylamines and extended Silicon- Oxygen compounds, Carbides and Silicides. Complexes of Ge, Sn and Pb, Diamond, graphite and other forms of carbon, Hydrides of group V and VI elements, Phosphanes, phosphorous halides and phosphazenes, Oxohalides and Oxoacids of P, S, Se and Te, Oxoacids of halogens, Interhalogen compounds and polihalides,Chemistry of noble gases, Compounds of Xenon (structure and reactivity), Clathrates.	**1,2,3**
2	**Structural Aspects and Bonding:** Structures and Isomers of Coordination Complexes, Classification of complexes based on coordination numbers and possible geometries, sigma and pi bonding ligands such as CO, NO, CN^-, R3P, and Ar3P, Stability of complexes, thermodynamic aspects of complex formation-Irving William order of stability, chelate effect.Werners cordination theory,Valence Bond theory, Crystal Field Theory, Splitting of d orbitals in octahedral, tetrahedral, square planar, square pyramidal and triagonal bipyramidal fields, LFSE, Dq values, Jahn Teller (JT) effect, theoretical failure of crystal field theory, evidence of covalency in the metal-ligand bond, nephelauxetic effect, ligand field theory, molecular orbital theory- M. O energy level diagrams for octahedral and tetrahedral complexes without and with π-bonding, experimental evidences for pi-bonding	**4,5,6**
3	**Spectral and Magnetic Properties of Metal Complexes** Electronic Spectra of complexes: Term symbols of dn system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields, correlation diagrams for d1 and d9 ions in octahedral and tetrahedral fields (qualitative approach), d-d transitions, selection rules for electronic transitions. Interpretation of electronic spectra of complexes: Orgel diagrams and demerits, Tanabe Sugano diagrams, calculation of Dq, B and β (Nephelauxetic ratio) values, spectra of complexes with lower symmetries, charge transfer spectra, luminescence spectra. Magnetic properties of complexes-paramagnetic and diamagnetic complexes, spin only magnetic moment, Temperature dependence of magnetism- Curie's law, Curie-Weiss law, temperature independent paramagnetism (TIP), spin state cross over, antiferromagnetism-inter and intra molecular interaction, anomalous magnetic moments	**7,8,9**

4	**Kinetics and Mechanism of Reactions in Metal Complexes** Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic substitution reactions in square planar complexes- trans effect-theory and applications. Substitution in tetrahedral and five-coordinate complexes ,Kinetics and mechanism of octahedral substitution- water exchange, dissociative and associative mechanisms, base hydrolysis, racemization reactions, solvolytic reactions (acidic and basic), Replacement reactions involving multidendate ligands- formation of chelates, effect of H+ on the rates of substitution of chelate complexes, metal ion assisted and ligand assisted dechelation, Electron transfer reactions: Outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism, mixed outer and inner sphere reactions, two electron transfer and intramolecular electron transfer	**10,11**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry: A Comprehensive Text, 3rd Edn., Interscience,1972
2. J. E. Huheey, E. A. Keiter, R. A. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Pearson Education India, 2006
3. K. F. Purcell, J. C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977
4. F. Basolo, R. G. Pearson, Mechanisms of Inorganic Reaction, John Wiley & Sons, 2006
5. E. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007
6. R. S. Drago, Physical Methods in Chemistry, Saunders College, 1992
7. B. N. Figgis, M. A. Hitchman, Ligand Field Theory and its Applications, Wiley-India, 2010
8. J. D. Lee, Concise Inorganic Chemistry, 4th Edn., Wiley-India, 2008
9. R. G. Wilkins, Kinetics and Mechanisms of Reactions of Transition Metal Complexes, Wiley VCH, 2002
10. G. A. Lawrance, Introduction to Coordination Chemistry, John Wiley & Sons Ltd, 2010
11. E. Housecroft, A. G. Sharpe, Inorganic Chemistry, Pearson, 2012
12. F. Shriver, P. W. Atkins, Inorganic Chemistry, 5thEdn., Oxford University Press, 2010.
13. Organometallic Chemistry (Coordination Chemistry Fundamentals), edited by Hiroshi Nakazava, Julian Koe ISBN 9781839164064, published by Royal society of Chemistry 2021

Programme	**Joint M.Sc.**
Course Name	**Structural and Molecular Organic Chemistry**
Type of Course	**Core**
Credit Value	**3**
Course Code	MGKUMPNSC31

Course Summary & Justification	The course is designed to address the fundamental concepts and mechanisms of organic and photochemical reactions, basic organic reaction mechanisms, stereochemistry and conformational analysis of organic compounds. Through this learning, the students will be able to describe the chemical and molecular processes that take place in organic chemical reactions, and to differentiate various types of nucleophilic substitution and elimination reactions. They are suggested to understand the basic concepts and various types of aromaticity, and also to have a knowledge of stereochemical aspects of organic reactions. A good understanding of types of isomerism and stereochemical notations are also advisable. This course would help the students to grasp the aforementioned domains with thorough learning and practice.					
Semester	**1**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	0	40	120
Prerequisite	Fundamentals of organic chemistry and stereochemical notations					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1.	To revise and understand basic concepts of aromaticity and electron displacement effects	R, U	1,5
2.	To illustrate the reaction mechanism aspects in the context of addition, elimination and substitution reactions	U, An, E	1,5
3.	To predict the mechanisms of different organic reactions	An, A, S	1,5
4.	To have a thorough knowledge of different types of isomerism	R, U, Ap	1,5
5.	To demonstrate chirality in organic molecules using units such as center, axial, planar, and helicity.	U, E,	1,5
6.	To predict E/Z configuration in organic molecules by applying concepts of stereochemistry	A, An, S	1,5
7.	To learn basic concepts of organic photochemistry, and to summarize photochemical intermediates involved in organic reactions	U, An, I	1,5
8.	To learn the basic difference between photochemical and thermal reactions	U, E, Ap	1,5
9.	To gain knowledge on the synthetic applications of organic photochemical reactions	U, Ap	1,5,7
10	To develop skill to propose the possible mechanism of a given photochemical reaction	A, S	1,3,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Structural and Molecular Aspects of Organic Chemistry** Review of basic concepts in organic chemistry: Bonding, hybridization, MO picture of butadiene and allyl systems, Electron displacement effects: Inductive effect, electromeric effect, resonance effect, hyperconjugation, steric effect, Bonding weaker than covalent bonds. Concept of aromaticity: Delocalization of electrons – Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems – annulenes, carbon nanotubes and graphene.	**1**
2	**Organic Reaction Mechanisms 1** Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples, Arenium ion intermediates, S_N1, S_N2, mixed S_N1 and S_N2, S_NAr, $S_{RN}1$, S_Ni, SE1, SE2 and benzyne mechanisms, E_2, E_1 and E_1CB mechanisms. Hoffman and Saytzeff modes of elimination, orientation of the double bond. Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles, regio- and chemo selectivity orientation and reactivity. Markovnikov's and anti-Markovnikov's mechanisms. Effect of substrate, reagent, leaving group, solvent and neighbouring group on nucleophilic substitution (S_N2 and S_N1) and elimination (E_1 and E_2) reactions.	**2,3**
3	**Stereochemistry of Organic Compounds** Stereochemistry of Organic Compounds: Stereoisomerism: Definition based on symmetry and energy criteria, configuration and conformational stereoisomers, Centre of chirality: Molecules with C, N, S based chiral centres, absolute configuration, enantiomers, racemic modifications, R and S nomenclature using Cahn-Ingold-Prelog rules, molecules with a chiral centre and Cn, molecules with more than one centre of chirality, definition of diastereoisomers, constitutionally symmetrical and unsymmetrical chiral molecules, 14rythron and threo nomenclature. Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidene cycloalkanes, Topicity and prostereo isomerism, topicity of ligands and faces as well as their nomenclature, NMR distinction of enantiotopic/diastereotopic ligands. Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers, interconversion of geometrical isomers.	**4,5,6**
4	**Photochemistry of Organic compounds** Franck-Condon principle, Jablonski diagram, fluorescence and phosphorescence, Singlet and triplet states, Photosensitization, Quantum efficiency, Photochemistry of carbonyl compounds, Norrish type-I and type-II cleavages, Paterno-Buchi reaction, Photoreduction, Photochemistry of enones and para-benzoquinones, Di π – methane rearrangement, Photodynamic therapy, Photochemical [4+2] cycloaddition using singlet Oxygen; Barton reaction	**7,8,9,10**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.
2. Jerry March, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure.
3. T.H. Lowry, K.S. Richardson, Mechanism and Theory in Organic Chemistry, 2nd Edn., Harper & Row, 1981.
4. N.S. Isaacs, Physical Organic Chemistry, ELBS/Longman, 1987.
5. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press, 2002.
6. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th Edn., Springer, 2007.

C. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 3rdEdn., New Age Pub., 2010.

7. D.G. Morris, Stereochemistry, RSC, 2001.
8. E.L. Eliel, S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley & Sons, 1994.
9. N.J. Turro, V. Ramamurthy, J.C. Scaiano, Principles of Molecular Photochemistry: An Introduction, University Science books, 2009.
10. N.J. Turro, Modern Molecular Photochemistry, Benjamin Cummings, 1978.
11. K.K.R. Mukherjee, Fundamentals of Photochemistry, New Age Pub., 1978
12. Harold H. Trimm, Organic Chemistry: Structure and Mechanisms (Research Progress in Chemistry), Apple Academic Press, 2021.
13. K. Peter C. Vollhardt , Neil E. Schore, Organic Chemistry: Structure and Function Eighth Edition, 2018.
14. Paula Yurkanis Bruice, Organic Chemistry - 8th Edition, Pearson Eduacation, 2020

Programme	**Joint M.Sc.**
Course Name	Advanced Quantum Mechanics and Group Theory
Type of Course	Core
Credit Value	3
Course Code	MGKUMPNSC32

Course Summary & Justification	This course aims to equip students with advanced knowledge of quantum mechanics necessary to conduct research and understand literature. This course introduces basic concepts of molecular symmetry and group theory in detail. Further it also discusses different aspects of advanced chemical dynamics					
Semester	I					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	0	40	120
Pre-requisite	Quantum theory, statistical mechanics, thermodynamics (Undergraduate level). Strong mathematical skill in Differential Equations and Linear Algebra.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Describe advanced symmetry concepts of chemical molecules and its applications.	U	1,5,7
2	To identify the concept of axis, plane, centre and the point group.	U	1,5
3	To describe product of symmetry operation and character table of chemical compounds.	U, A	1,5
4	Make use character table to predict the spectroscopic properties of the molecule	U, A, E	1,5,7
5	Explain the application of Schrodinger equation to rotational and vibrational model systems	U	1,5
6	Describe the quantum mechanical explanation of orbitals and chemical bonding.	U, R	1,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Module 1** **Group Theory and Applications in Chemical Bonding and Spectroscopy** Symmetry elements and symmetry operations. 1.2. Determination of point groups of molecules and ions (organic / inorganic / complex) belonging to Cn, Cs, Ci , Cnv, Cnh, C∞v, Dnh, D∞h, Dnd, Td and Oh point groups. 1.3. Symmetry in crystals:32 crystallographic point groups (no derivation), Hermann Mauguin symbols. Screw axis-pitch and fold of screw axis, glide planes, space groups(elementary idea only) 1.4. Mathematical groups :Properties, Abelian groups, cyclic groups, sub groups, similarity transformation ,classes - C2v, C3v and C2h. 1.5. Group multiplication tables (GMTs) - C2v, C3v and C2h, isomorphic groups. 1.6. Matrix representation of elements like E,Cn,Sn,I, σ-matrix representation of point groups like C2v,C3v,C2h,C4v - trace /character, block factored matrices. 1.7. Reducible and irreducible representations, standard reduction formula, statement of great orthogonality theorem (GOT). , construction of character tables for C2v, C2h, C3v and C4v. 1.8. Application in chemical bonding:Projection operator, transformation properties of atomic orbitals, construction of symmetry adapted linear combination of atomic orbitals (SALCs) of C2v, C3v,D3h and C2h molecules. 1.9 Applications in vibrational spectra: transition moment integral, vanishing of integrals, symmetry aspects of molecular vibrations. Determination of the symmetry of normal modes of C2v, C3v and C2h point groups using Cartesian coordinates and internal coordinates. Complementary character of IR and Raman spectra determination of the number of active IR and Raman lines in Td, Oh and Square planar complexes	**1,2,3,4**
2	**Module 2** **Quantum Mechanics and Applications** Introduction to quantum mechanics, failure of classical mechanics, need of quantum mechanics, black body radiation, photoelectric effect, atomic spectra, wave-particle duality. Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and nature of its solutions, Born interpretation of the wave function. Model system: particle in 1D box, quantization of energy levels, zero-point energy, probability distribution functions, normalized and orthogonal wave functions. Extension to two- and three-dimensional box problems, separation of variables and degeneracy of wave function. Qualitative treatment of hydrogen atom and hydrogen-like ions, significance of quantum numbers, radial and angular wave functions for hydrogen atom.	**5,6**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. N. Levine, Quantum Chemistry, 7 th Edn., Pearson Education Inc., 2016.
2. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4 th Edn., Oxford University Press, 2005.
3. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
4. R. Anatharaman, Fundamentals of Quantum Chemistry, Macmillan India, 2001.
5. F. A. Cotton, Chemical Applications of Group Theory, 3 rd Edn., Wiley Eastern, 1990
6. L. H. Hall, Group Theory and Symmetry in Chemistry, McGraw Hill,1969
7. V. Ramakrishnan, M. S. Gopinathan, Group Theory in Chemistry, Vishal Publications, 1992
8. S. Swarnalakshmi, T. Saroja, R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008
9. S. F. A. Kettle, Symmetry and Structure: Readable Group Theory for Chemists, 3rd Edn., Wiley, 2007.
10. S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2010
11. A. McQuarrie, J. D. Simon, Physical Chemistry – a molecular approach, Viva Books, 1998.
12. N. Levine, Physical Chemistry, 5th Ed., Tata-McGraw-Hill.
13. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press, 2009.
14. A. Vincent, Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications, 2 nd Edn., Wiley, 2000

Programme	**Joint M.Sc.**
Course Name	Physical Chemistry I
Type of Course	Core
Credit Value	3
Course Code	MGKUMPNSC33

<table>
<tr><td>Course Summary & Justification</td><td colspan="6">In a broader sense, physical chemistry can be defined as the application of physics to chemistry. The physics explains the world around us by building various models. The models such as kinetic theory of gases, collision theory of reactions etc. are purely classical-based. In contrast, for subatomic world, one needs to go beyond classical world and invoke the laws of quantum mechanics to describe small particles like electron. In classical and quantum worlds alike, the physics needs the support of mathematics to construct its models. Thus, much of physical chemistry is inherently mathematical and can be conceived faster through exercises and problem solving. Therefore, a recommended approach to succeed in physical chemistry is to solve as many end-of-chapter problems as possible.

This course introduces students to the core area of physical chemistry, based around the themes of systems, states and processes. Topics covered are Quantum mechanics, Classical thermodynamics, Statistical mechanics and Chemical kinetics. Throughout the course, the relationship between physical phenomena and the molecular structure and reactions underpinning advanced materials will be highlighted. The general goal of learning physical chemistry is to obtain an in-depth understanding of why and how chemical reactions occur, which in turn may enable us to accurately design reactions leading to novel molecules of the future.</td></tr>
<tr><td>Semester</td><td colspan="6">I</td></tr>
<tr><td>Total Student Learning Time (SLT)</td><td>Learning Approach</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Others</td><td>Total Learning Hours</td></tr>
<tr><td></td><td></td><td>40</td><td>40</td><td>0</td><td>40</td><td>120</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Quantum theory, statistical mechanics, thermodynamics and kinetics (Undergraduate level). Strong mathematical skill in Differential Equations and Linear Algebra.</td></tr>
</table>

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To understand the rate of different types of reactions	U	1,5
2	To understand variable order reactions, steady state approximation etc	U, A	1,5
3	To study various theories associated with rate of reaction.	U, R	1,5
4	Understand a comprehensive and rigorous treatment of classical thermodynamics.	U	1,5
5	Understand transformations at the molecular level.	U	1,5
6	Evaluate Phase behavior of one and two component systems.	U, A	1,5
7	State and apply basic concepts of thermodynamics into mixtures, Understand thermodynamics of ideal and non-ideal solutions.	U, An	1,5
8	Find the connection between statistics and thermodynamics and differentiate between different ensemble theories used to explain the behaviour of the systems.	U, A, An	1,5
9	To understand the properties of macroscopic systems using the knowledge of the properties of individual particles, thermodynamic probability, macroscopic and microscopic states.	U, A	1,5
10	To understand various photophysical reactions.	U, A	1,5,7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Module 1** **Chemical Kinetics and Catalysis** Reaction rates and order of reactions, determination of order of reactions, complex reactions (free radical chain reactions, branching reactions, hydrogen-oxygen and hydrogen-halogen reactions). Reversible, consecutive and opposing reactions. The Analysis of kinetics results: the method of integration, graphical methods, half-life methods, Guggenhiem's method, the differential method. Reactions of variable order, steady state treatment, free radical reactions. Studies of fast reactions by flow method, relaxation method and flash photolysis. Theories of unimolecular reaction and their treatments (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus (RRKM) theory. Collision theories of reaction rates, steric factors. Arrhenius equation, activated complex theory, Collision cross section and reaction cross section. Collision theory. Potential energy surfaces and reaction coordinate. Transition state theory. Kinetic theory of gases, transport properties in gases. Kinetics of reactions in solution, diffusion-controlled reactions, effect of solvent on rates of reactions, kinetic salt effect, homogeneous catalysis and heterogeneous catalysis.	**1,2,3**
2	**Module 2** **Classical Thermodynamics** Mathematical foundations for thermodynamics-variables of thermodynamics, extensive and intensive quantities, equation for total differential, conversion formulas, exact differentials, general formulation, reciprocity characteristics, homogeneous functions, Euler's theorem. Concepts of entropy and free energy: Entropy as measure of randomness and unavailable energy. Entropy changes in reversible and irreversible process and during various processes. Clausius inequality. Variation of entropy with T and P. Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Maxwell's relations, Von't Hoff's reaction isotherm and isochore, Gibbs-Helmholtz equation. Determination of free energy changes. Nernst heat theorem and third law of thermodynamics- calculation of absolute entropies and residual entropy. Partial molar Properties: Physical significance, Partial molar volume and partial molar free energy (chemical potential). Determination of partial molar quantities by intercept method and slope methods. Physical significance of chemical potential. Variation of chemical potential with temperature and pressure. Formulation of the Gibbs Duhem equation. Derivation of Duhem-Margules equation.	**4,5,6,7**

3	**Module 3** **Statistical Mechanics** Brief history about the macroscopic and microscopic approach in science, permutation, probability, Stirling's approximation, macrostate and microstates, equal a priori principle and thermodynamic probability, thermodynamic probability and entropy, phase-space, ensemble, types of ensembles. Boltzmann distribution law, partition function and its physical significance, relation between molecular partition function and molar partition function, distinguishable and indistinguishable particles, partition function and thermodynamic functions, separation of partition function- translational, rotational, vibrational, and electronic partition functions, partition function for hydrogen. Thermal de-Broglie wavelength. Calculation of thermodynamic functions and equilibrium constants, Sackur-Tetrode equation, statistical formulation of third law of thermodynamics, residual entropy, heat capacity of gases - classical and quantum theories. Heat capacity of solids: the vibrational properties of solids, Dulong and Petit's law, Einstein's theory and its limitations, Debye theory and its limitations. Need for quantum statistics, Bosons and Fermions, Bose-Einstein statistics: Bose- Einstein distribution law, Bose-Einstein condensation, first order and higher order phase transitions, liquid helium, Fermi-Dirac statistics: Fermi-Dirac distribution law, application in electron gas, thermionic emission. Comparison of three statistic.	**8,9**
4	**Module 4** **Photochemistry** Photophysical processes of electronically excited molecules- Franck – Condon principle– quantum mechanical treatment-Dissociation and pre – dissociation of diatomic molecules Energy transfer from electronically excited molecules- Stern – Volmer mechanism only Photophysical pathways: fluorescence, phosphorescence, E-type and P- type delayed fluorescence. Kinetic treatment of excimer and exciplex formation- lasers in photochemical kinetics- Photochemical splitting of water- organic light emitting devices.	**10**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. D. A. McQuarrie, J. D. Simon, Physical Chemistry – a molecular approach, Viva Books, 1998.
2. I. N. Levine, Physical Chemistry, 6th Ed., Tata-McGraw-Hill.2009.
3. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press, 2009.
4. P. Atkins, J. de Paula, and J. Keeler, Physical Chemistry, 11th Edn. Oxford University Press, Oxford 2018. 12 th. Edn. 2022.
5. D. A. McQuarrie and J. D. Simon, Molecular Thermodynamics, University Science Books, California, 2004.
6. R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry, 2nd Edition, Oxford University Press, Oxford, 2007.
7. D. A. McQuarrie, Statistical Mechanics, University Science Books, California 2005.
8. B. Widom, Statistical Mechanics - A Concise Introduction for Chemists, Cambridge, University Press, 2002.
9. K. J. Laidler, Chemical kinetics, 3rdEdn. , Harper & Row, 1987.
10. C. Kalidas, Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, New Age International, 2005.
11. J. W. Moore, R. G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, 1981.
12. J. G. Calvert and J. N. Pitts, Photochemistry, *Edn. 1*, New York: *John* Wiley & Sons.1966.
13. N. J. Turro, "Modern Molecular Photochemistry" (MMP), University Press, Menlo Park, CA, 1978.
14. A. Gilbert and J. Baggott, "Essentials of Molecular Photochemistry," CRC Press, London, UK, 1991.

Programme	**Joint M.Sc.**
Course Name	Introduction to Nanomaterials
Type of Course	Core
Credit Value	3
Course Code	MGKUMPNSC34

Course Summary & Justification	The emphasis of the course is to understand the chemistry of Nanomaterials in detail and to explore the wide application. This course provides research-focused teaching and training for post graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of the principles governing nano and functional materials properties, behaviour and interactions. Also, this course aims to; Understand and use the properties of Nano-materials in diverse fields. Gain knowledge about the Nanomaterials, their properties, behaviour, interaction and use of them over many disciplines of science. The emphasis of the course is to understand the Nanomaterials in detail and to explore the wide application. Highlights of the course is to provided virtual way of understanding the courses materials. Specially the application-based approach.					
Semester	I					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	0	40	120
Pre-requisite	Understanding of Solid state (Undergraduate level).					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand and use the properties of Nano-materials in diverse fields.	U	1,5
2	Gain knowledge about the Nanomaterials, their properties, behaviour, interaction and use of them over many disciplines of science.	U, A	1,5

3	Understand the chemistry of Nanomaterials in detail and to explore the wide application.	U, R	1,5
4	Understand the constituents of matter, nanomaterials, properties and usefulness.	U	1,5
5	Able to learn how to understand the basic behaviour of Nanomaterials.	U	1,5
6	Understand size and shape dependent properties of Nanomaterials.	U, A	1,5
7	Gain knowledge about classification of Nanomaterials	U, An	1,5
8	Deep understanding on surface characteristics of Nanomaterials	U, A, An	1,5
9	Able to understand different surface energy minimization techniques.	U, A	1,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		**CO No.**
1	**Fundamentals of Nanomaterials** History of Nanotechnology, Feynman's vision on Nano Science & technology, bulk vs nanomaterials. Central importance of nanoscale morphology - small things making big differences, nanotechnology as natures technology, clusters and magic numbers, nanoscale architecture. Recent developments, challenges and future prospects of nanomaterials.	**1,2,3,4,5**
2	**Size and shape dependent properties of nanomaterials** Size and shape dependent properties, Melting points and lattice constants, Surface Tension, density of states, Wettability - Specific Surface Area and Pore – Composite Structure - Mechanical properties, Optical properties: Basic principles of nanomaterials- Increase in surface area to volume ratio and quantum confinement effect. Surface plasmon resonance in metal nanoparticles and quantum size effect in in Semiconductors, Electrical conductivity: Surface scattering, change of electronic structure, quantum transport, effect of microstructure.	**6**
3	**Classification of nanomaterials** Classification based on the dimensionality, Zero-dimensional nanostructures: metal, semiconductor and oxide nanoparticles. One-dimensional nanostructures: nanowires and nanorods, Two-dimensional nanostructures: thin films, Three-dimensional nanomaterials, Special Nanomaterials: Carbon fullerenes and carbon nanotubes, micro and mesoporous materials, core-shell structures, organic-inorganic hybrids.	**7**

4	**Surface characteristics of Nanomaterials** Surface science for nanomaterials, surface energy, Surface Energy minimization: Sintering Ostwald ripening and agglomeration, Energy minimization by Isotropic and anisotropic surfaces, Wulff plot, Surface energy, surface curvature and chemical potential, Surface energy stabilization mechanisms, Electrostatic stabilization – Point zero charge (p.z.c), Nernst Equation, Electric double layer. Electric potential at the proximity of a solid surface - Debye-Huckel Screening strength. Interaction between nanoparticles – Van der Waals attraction potential, DLVO Theory, steric stabilization and electro steric stabilization. Nucleation and growth of nuclei, critical radius, homogenous and heterogeneous nucleation.	**8,9**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. G. Cao and Y. Wang, Nanostructures and Nanomaterials, 2nd Ed., Imperial College Press, 2004.
2. R. Kelsall, I. Hamley and M. Geoghegan, Nanoscale Science and Technology, Wiley, 2005.
3. K. J. Klabunde, R. M. Richards, Nanoscale Materials in Chemistry, 2nd Ed., Wiley, 2009.
4. T. Pradeep, A text book of Nano Science and Technology, Tata McGraw-Hill Education, 2012.
5. G. Schmidt, Nanoparticles: from Theory to applications, Wiley-VCH, 2004
6. G. Louis Horn yak, Introduction to nanoscience.
7. C.P. Poole, Introduction to nanotechnology.
8. Introduction to Nanoscale Science and Technology *Edited By* Massimiliano Ventra, Stephane Evoy, James R. Heflin*; ISBN* 978-1-4020-7757-9, *Published by Apple academic Press, 2013*
9. Characterization of Nanomaterials Advances and Key Technologies *Edited By* Sneha Mohan Bhagyaraj, Oluwatobi Samuel Oluwafemi, Nandakumar Kalarikkal, Sabu Thomas *; ISBN* 9780081019733, *Published by Elsevier, 2018*

Programme	**Joint M.Sc.**
Course Name	Practical I - Organic Chemistry
Type of Course	Core
Credit Value	2
Course Code	MGKUMPNSC35

Course Summary & Justification	This course is designed to give the student an awareness about the safety measures to be taken in the lab, familiarizing the different glassware and equipments used, separation of the components present in the given binary mixture organic compounds using appropriate separation methods and analyzing the separated components using standard procedures. Students will learn how to apply common laboratory techniques to determine the structure, reactivity and analysis of organic compounds. Preparation of different organic molecules from simple molecules is also included in the course. They will become familiar with the nomenclature and behavior of organic functional groups through reactions and instrumental analysis. Characterisation of organic compounds by means of spectroscopic methods (IR, NMR and UV-Visible) are also included. Students will also be taught tools such as ChemDraw / Chemsketch which will be very handy in their future studies and career.					
Semester	1					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
			40	40		80
Prerequisite	Basic knowledge in practical organic chemistry.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To handle organic chemicals, glassware and precautions to be taken for safety in a chemistry lab	R, U, A	1,3,4
2	To separate the components from a mixture using suitable methods and to analyse the components using various reagents and reactions	U, A, An, S	1,3,4
3	To perform experiments individually and to gain knowledge about principles and techniques involved in various separation experiments	An, A, S, I	1,3,4
4	To separate components in a mixture and its purity assessment	An, U, E, S	1,3,4,7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

	CO N O.
PART I. **Organic analysis** a) Separation of two-component mixtures b) Identification of individual components c) Separation, Purification and analysis of the components d) Preparation of their derivatives **e)** Determination of physical constants of the components and its derivatives	**1,2**
PART II. **General methods of separation and purification of organic compounds such as:** a) Thin Layer Chromatography b) Column Chromatography c) Solvent Extraction **d)** Soxhlet Extraction	**3**
PART III. Quantitative separation of organic mixtures by column chromatography and its purity assessment by TLC.	**4**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** Lab/Experiment skills Lab record/Report Viva-voce Lab Discipline (participation, punctuality, accuracy)

REFERENCES

1. I. Vogel, Elementary Practical Organic Chemistry, Longman, 1958
2. I. Vogel, A Textbook of Practical Organic Chemistry, Longman, 1974
3. R. M. Silverstein, G. C. Bassler, T. C. Merril, Spectrometric Identification of Organic Compounds, John Wiley & Sons, 1981
4. Pasto, C.R. Johnson, M. J. Miller, Experiments and Techniques in Organic Chemistry, Prentice Hall, 1992
5. F. G. Mann, B. C Saunders, Practical Organic Chemistry, 4th Edn., Pearson Education India, 2009
6. R. Adams, J. R. Johnson, J. F.Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979
7. M. P. Doyle, W.S. Mungall, Experimental Organic Chemistry, John Wiley & Sons, 1980
8. Advanced Practical Organic Chemistry, Edited *By John Leonard, Barry Lygo, Garry Procter ISBN*9781138494145 Published by CRC Press 2013

Programme	**Joint M.Sc.**
Course Name	Practical II - Inorganic Chemistry
Type of Course	Core
Credit Value	2
Course Code	MGKUMPNSC36

Course Summary & Justification	The laboratory practical course enables the students to understand and apply the lab skills and laboratory safety procedures needed to carry out standard chemistry experimental techniques. This course will facilitate the students to apply the basic concepts of inorganic chemistry to analyze the metal ions in a given sample. Through this course the students will learn to (i) separate and identify cations in a given mixture (ii) estimate the metal ions using colorimetry (iii) perform complexometric titrations of metal ions with double burette method (iv) separate and estimate binary mixture of metal ions using combined volumetric and colorimetric methods and (v) tabulate and analyze the results of all the experiments systematically. This course will improve the analytical skill and critical thinking including observation, hypothesis development, measurement and data collection, experimentation, evaluation of evidence, and employment of mathematical analysis.					
Semester	I					
Total StudentLearning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total LearningHours
			40	40		80
Pre-requisite	The chemistry laboratory is a place of discovery and learning but at the same time it can be a place of danger if proper common-sense of precautions are not taken care. So the students are expected to learn and follow the general safety guidelines to ensure a safe laboratory environment. Also a basic knowledge on inorganic salt analysis, colorimetric estimations and complexometric titrations is preferred.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Perform basic chemical lab procedures by following appropriate lab safety measures & Infer the experimental results with mathematical and analytical reasoning.	U	1,3,4
2	Separation and identification of the mixture of cations in a given sample	A, An, S	1,3,4
3	Estimation of the amount of metal ion present in the whole of the given solution colorimetrically	A, An,S	1,3,4,6
4	Preparation and characterization complexes using IR, NMR and electronic spectra	U, An, S	1,3,4,6,7
5	Develop the skills to carry out basic quantitative and qualitative analytical techniques	S	1,2,3,4,6
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

	CO No.
PART I **Separation and identification of a mixture of four cations** A mixture of two familiar ions such as Ag+ , Hg2+, Pb2+, Cu2+, Bi2+, Cd2+, As3+, Sn2+, Sb3+, Fe2+, Fe3+, Al3+, Cr3+, Zn2+ , Mn2+ , Co2+, Ni2+, Ca2+, Sr2+, Ba2+, Mg2+, Li+ , Na+ , K+ and NH4+ and two less familiar metal ions such as Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li), Anions which need elimination not to be given, Minimum eight mixtures to be given.	**1,2**
PART II Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, NH4+, nitrate and phosphate ions.	**3**
PART III **Preparation and characterization complexes using IR, NMR and electronic spectra,** a) Tris (thiourea)copper(I) complex b) Potassium tris (oxalate) aluminate (III) c) Hexammine cobalt (III) chloride d) Tetrammine copper (II) sulphate e) Schiff base complexes of various divalent metal ions f) Bis(dimethylglyoximato) nickel (II) **g)** Prussian blue	**4,5**

TeachingandLearningApproach	**Classroom Procedure (Mode of transaction)** 1. Direct Instruction: Lecture, Explicit Teaching, E-learning 2. Interactive Instruction: Active co-operative learning, Authentic learning
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Two internal tests b. Lab skill c. Attendance d. Viva voce e. Lab record B. Semester End examination

REFERENCES

1. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn, Longman, 1996.
2. I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman. 1966.
3. M. Koltoff, E. B. Sandell, A Text Book of Quantitative Inorganic Analysis, 3rd McMillian, 1968.
4. V. V. Ramanujam, Inorganic Semimicro qualitative Analysis. The National Public Co. 1974.
5. J. Singh, R. K. P. Singh, J. Singh, LDS Yadav, I. R. Siddiqui, J. Shrivastava, Advanced Practical Chemistry, Pragati Prakashan, 7th Edn., 2017

Programme	**Joint M.Sc.**
Course Name	Surface Chemistry and Catalysis
Type of Course	Elective
Credit Value	4
Course Code	MGKUMPNSE12

Course Summary & Justification	Introduce the main techniques of surface science and to understand how these techniques can be used to investigate the structure, composition and reactivity of surfaces with a particular focus on systems of relevance to heterogeneous catalysis. To introduce the important general concepts of the chemistry of heterogeneous catalysis and to describe and illustrate the main types.					
Semester	I					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		60	40	0	40	140
Pre-requisite	Bachelor's degree in chemistry, with physics and mathematics as subsidiaries.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To introduce the concepts of adsorption and desorption	U	1,5
2	To explain many of the proposed hypotheses of surfaces in terms of fundamental concepts.	A	1,5
3	Be able to apply the knowledge in order to predict and rationalize the properties of catalysts.	Ap	1,5
4	To study various characterisation techniques	A, U	
5	To understand the role of a catalyst in relation to thermodynamics and to appreciate the relevance of catalyst activity, selectivity, deactivation and regeneration.	A	1,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Adsorption at Liquid Surfaces** Adsorption at liquid surfaces - Gibb's equation and its verification, adsorption forces, Thermodynamics of physical adsorption, Heat of adsorption and its determination.	1,2,3
2	**Adsorption on Solids** Adsorption on solids, Langmuir adsorption isotherm, Multilayer adsorption, BET and Polanyi models for the adsorption. Electrical phenomena at interfaces including electrokinetic potentials, Micelles, Critical Micelle Concentration (CMC). Relevance of surfaces and interfaces: colloids, nanomaterials & biology	1,2,3
3	**Characterization of Solid Surfaces** Harkins and Jura equation and other methods for measurements of surface area of solids, Diffraction and thermal methods - Powder X-Ray diffraction-peak broadening and particle size analysis, N_2 adsorption -surface area, pore size analysis, thermal analysis using TGA and DTA, Morphology and particle size analysis - SEM, AFM and HR-TEM.	4
4	**Adsorption Behaviour of Porous Materials** Porous solids, Pore size distribution, Adsorption behaviour of porous materials, hysteresis of adsorption, Theory of surface reactions, Molecular sieves, Capillary condensation, micro-pore analysis.	2
5	**Catalysis** Homogeneous catalysis, Autocatalysis and oscillating reaction, Kinetics of homogeneous catalysis, Heterogeneous catalysis, Kinetics of heterogeneous catalysis, Development of catalysts, Enzyme catalysis.	5

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, Oxford University Press, 9th Edition, Reprinted 2011.
2. P. Atkins' Physical Chemistry, 11th Edition by P. Bolgar, H. Lloyd, A. North, V. Oleinikovas, S. Smith, J. Keeler, Oxford University Press, 2017
3. J. M. Thomas, W. J. Thomas, Principles and Practice of Heterogeneous Catalysis, Wiley, 2015
4. Chorkendorff, J. W. Niemantsverdriet, Concepts of Modern Catalysis and Kinetics, Wiley, 2007

Programme	**Joint M.Sc.**
Course Name	Nanocomposites
Type of Course	Elective
Credit Value	4
Course Code	MGKUMPNSE13

Course Summary & Justification	Students will gain some knowledge of the main types of nanocomposite materials and their specific physical and chemical properties required in applications. Graduates will become familiar with the methods of preparation and characterization of specific physical properties of nanocomposite materials. The current state of theory and modelling of nanocomposites will be presented. At the end of the course, students will have enough understanding of the main concepts in nanocomposites physics to allow them read and understand the most important research papers in this field.					
Semester	1		Credit			
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Basics of Nanochemistry (Undergraduate)					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Understand Metal based nanocomposite: preparation techniques and their final properties and functionality (Module 1)	U, A	1
2	Study of Ceramic based nanocomposites: some preparation techniques, properties and applications.	U, A	1,7

	(Module 2)		
3	Introduction of Polymer based nanocomposites, Diblock Copolymer based nanocomposites: preparation, properties and applications. Carbon nanotubes-based nanocomposites: functionalization of CNTs will also be discussed. (Module 3).	An, E	7
4	Introduction of new kind of nanocomposites, Design of super hard materials, Super hard nanocomposites, its designing and improvements of mechanical properties will also be discussed. (Module 4)	E	7, 9
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		**CO No.**
1	**Metal based nanocomposites:** Metal- oxide or metal-ceramic composites: different aspects of their preparation techniques and their final properties and functionality. Metal - metal nanocomposites: some simple preparation techniques and their new electrical and magnetic properties	**1**
2	**Ceramic based nanocomposites:** Different types of ceramic based nanocomposites, preparation techniques, properties and applications.	**2**
3	**Polymer based nanocomposites:** Thermoplastics, Thermosetting plastics and Elastomers Diblock Copolymer based nanocomposites: preparation, properties and applications. Polymer- carbon nanotubes-based nanocomposites: functionalization of CNTs, preparation, properties and applications. Elastomeric polymer nanocomposites	**3**
4	**Fractal based glass – metal nanocomposites and Super hard nanocomposites** Fractal blasted glass- metal nanocomposites, its designing and fractal dimension analysis, Electrical property of fractal-based nanocomposites, Core-shell structured nanocomposites, Design of super hard materials, Super hard nanocomposites, its designing and improvements of mechanical properties	**4**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	**Mode of Assessment** Continuous Internal Assessment (CIA) Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Assignments Semester End examination

REFERENCES

1. Nanocomposites Science and Technology – P. M. Ajayan, L. S. Schadler, P. V. Braum, Wiley, 2003
2. Physical properties of Carbon nanotube- R. Satio, Imperial College Press, 1998
3. Polymer nanocomposites, Edited by Yiu-Wing Mai and Zhong -Zeng Yu, Woodhead Publishing, 2006
4. Processing and properties of Nanocomposites, Suresh Advani, World Scientific Publishing, 2007
5. Polymer- Layered Silicate and Silicate and Silica Nanocomposites, Y. C. Ke and P. Stroeve, Elsevier Science, 2005
6. Novel synthesis and characterization of Nanostructured materials, Annelise Kopp Alves, Carlos P. Bergmann, Felipe Amorim Berutti, Springer, 2013
7. Composites and Nanocomposites, *Edited By*_A. K. Haghi, Oluwatobi Samuel Oluwafemi, Josmin P. Jose, Hanna J. Maria*; ISBN* 9781926895284, *Published by Apple academic Press, 2013*
8. NANOCOMPOSITE MATERIALS,Synthesis, Properties and Applications, *Edited By* Jyotishkumar Parameswaranpillai, Nishar Hameed, Thomas Kurian, Yingfeng Yu, *; ISBN* 13: 978-1-4822-5807-3 , *Published by CRC Press, 2017*

SEMESTER II

Programme	**Joint M.Sc.**
Course Name	Organometallics and Bioinorganic chemistry
Type of Course	Core
Credit Value	4
Course Code	MGKUMPNSC37

ourse Summary & Justification	This course introduces the basic concepts of organometallic chemistry with emphasis on transition metal complexes. The students will understand the structure and bonding of organometallic complexes bearing various σ-bonded and π-bonded ligands. They will learn about the unique reactions shown by organometallic compounds and its mechanism. This course highlights the application of organometallics in catalysis that is industrially important This course provides the students a detailed knowledge on fundamental aspects of the bioinorganic chemistry. The students will understand the role of metal ions and inorganic complexes in biological processes. They will learn about metal toxicity as well as the application of inorganic complexes as therapeutics. This course will give a strong foundation to carry out research on metalloenzyme applications, inorganic biomaterials and pharmaceutical development.					
Semester	II					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	60	40	0	40	140
Pre-requisite	Basic knowledge in Inorganic Chemistry					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the fundamental concepts of organometallic complexes such as 18 electron rules.	U	1,5

2	Explain and rationalize the structure and bonding of organometallic compounds with σ- and π-bonded ligands	U	1,5
3	Apply spectroscopic techniques to characterize organometallic compounds	U, A	1,5
4	Identify the fundamental reactions of organometallic compounds and its mechanism.	U, A	1,5
5	Describe the application of organometallics in catalysis	U	1,5
6	Apply the basic principles in inorganic and general chemistry to bioinorganic chemistry.	U, A	1,5
7	Understand the importance of metals in biological systems.	U	1,5
8	Remember the structure and functions of metalloproteins and metalloenzymes	U, R	1,5
9	Explain the role of metal ions which are involved in electron transfer reactions in biological systems.	U	1,7
10	Identify the metal centers involved in oxygen transport in living organisms and comprehend the mechanism of this process.	U	1,7
11	Understand the biological role of Iron, copper, zinc and molybdenum	U, R	1,7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		**CO No.**
1	**Reactions of Organometallic Compounds-Synthesis, Structure and Bonding** Haptonomenclature of organometallic compounds, organometallic compounds with linear pi donor ligands-olefins, acetylenes, dienes and allyl complexes-synthesis, structure and bonding, Synthesis and structure of complexes with cyclic pi donors, metallocenes and cyclic arene complexes, bonding in ferrocene and dibenzene chromium, carbene and carbyne complexes, Metal carbonyls: CO as a π-bonding ligand, synergism, preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, metal nitrosyls, metal cyanides and dinitrogen complexes, Polynuclear metal carbonyls with and without bridging, Carbonyl clusters-LNCCS and HNCCS, Isoelectronic and isolobal analogy, Wade-Mingos rules, cluster valence electrons, IR spectral studies of bridging and non-bridging CO ligands. Substitution reactions: Nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands, Addition and elimination reactions-1,2 additions to double bonds, carbonylation and decarbonylation, Oxidative addition- concerted addition, SN2, radical and ionic mechanisms, Reductive elimination- binuclear reductive elimination and σ-bond metathesis, Oxidative coupling and reductive decoupling, Insertion (migration) and elimination reactions – insertions of CO and alkenes, insertion into M−H versus M−R, α, β, γ and δ eliminations, Redistribution reactions, fluxional isomerism of allyl, cyclopentadienyl and allene systems.	**1,2,3,4**

2	**Catalysis by Organometallic Compounds**, Homogeneous and heterogeneous organometallic catalysis: Tolman catalytic loops, alkene hydrogenation using Wilkinson catalyst, Reactions of carbon monoxide and hydrogen-the water gas shift reaction, the FischerTropsch reaction (synthesis of gasoline), Hydroformylation of olefins using cobalt and rhodium catalysts, Polymerization by organometallic initiators and templates for chain propagation Ziegler Natta catalysts, polymerisation by metallocene catalysts, arbonylation reactions: Monsanto acetic acid process, olefin hydroformylation- oxo process, carbonylation of alkenes and alkynes in the presence of a nucleophile- the Reppe reaction, Carbonylation of aryl halides in the presence of a nucleophile. photodehydrogenation catalyst ("Platinum Pop"), Oxidation of olefins: Palladium catalyzed oxidation of ethylene-the Wacker process, epoxidation of olefins, hydroxylation by metal-oxo complexes, Asymmetric catalysis-Asymmetric hydrogenation, isomerization and epoxidation, C-H activation and functionalization of alkanes and arenes: Radicaltype oxidation, hydroxylation, dehydrogenation, carbonylation and regioselective borylation of alkanes and cycloalkanes, Radicaltype reactions, electrophilic reactions, carbonylation and borylation of arenes,	**5**
3	**Bioinorganic Compounds** Essential and trace elements in biological systems, toxic effects of metals (Cd, Hg, Cr,Pband As), structure and functions of biological membranes, mechanism of ion transport across membranes, sodium pump, ionophores, valinomycin, Phosphate esters in biology, Redox metalloenzymes, cytochromes-cytochrome P450, Oxygen carriers and oxygen transport proteins: Structure and functions of haemoglobins and myoglobin, oxygen transport mechanism, cooperativity, Bohreffect, Structure and functions of haemerythrinsandhaemocyanin, Biochemistry of zinc and copper: Structure and functions of carbonic anhydrase, carboxypeptidase A and superoxide dismutase	**6,7,8,9**
4	**Other important metal containing biomolecules**: Vitamin B12 and the vitamin B12 coenzymes, photosynthesis-chlorophyll a, PS I and PS II, Role of calcium in muscle contraction, blood clotting mechanism and biological calcification, Metals in medicine-therapeutic applications of cis-platin, radioisotopes and MRI agents.	**10,11**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Internal Test – MCQ based and descriptive answer type b. Seminar Presentation – the students will be given individual topics for seminar presentation c. Assignments d. Quizzes B. Semester End examination

REFERENCES

1. R. H. Crabtree, The organometallic Chemistry of Transition Metals 4th Edition, John Wiley, 2005.
2. J. P. Collman, L. G. Hegedus, J. R. Norton and R. G. Finke. Principles and Applications of Organotransition Metal Chemistry. Oxford University Press, 2nd Edition.
3. J.E. Huheey. R.A. Keiter, R.L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn., Prentice Hall, 1997.
4. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6thEdn., Wiley-Interscience, 1999.
5. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver and Atkins Inorganic Chemistry, 4th Edn., Oxford University Press, 2006.
6. J.D. Atwood, Inorganic and Organometallic Reaction Mechanism, Wiley-VCH, 1997.
7. B.E. Douglas, D.H. McDaniel, J. J. Alexander. Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007.
8. M. Bochmann, Organometallics and Catalysis : An Introduction, Oxford University Press, 2014.
9. W.K. Li, G.D. Zhou, T. Mak, Advanced Structural Inorganic Chemistry, Oxford University Press, 2008.
10. B.D. Gupta, A. J. Elias, Basis Organometallic Chemistry, Universities Press, 2013.
11. J.E. Huheey, R.A. Keiter, R.L. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Edn., Prentice Hall, 1997.
12. W. Kaim, B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, John Wiley & Sons, 1994.

Programme	Joint MSc
Course Name	Organic Reaction Mechanisms
Type of Course	Core
Credit Value	3
Course Code	MGKUMPNSC38

Course Summary & Justification	Starting from the very basic ideas, and moving towards the classification using different approaches, this course deals with advanced organic reaction mechanisms. The course guides through the involvement of reactive intermediates, their structure and reactivity through various organic reactions, as well as the basic concepts in molecular rearrangement reactions. The course is designed to acquaint the students with a detailed knowledge of physical organic chemistry, and ensures the students to understand and acquire knowledge on pericyclic reactions and name reactions, and their further applications in organic synthesis.					
Semester	II					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	0	40	120
Prerequisite	Basics of organic chemistry, stereochemistry, reaction mechanisms and pathways					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To revise and analyse the role of reactive intermediates such as carbocations, carbanions and non-classical carbocations in chemical reactions	R, U	1,5
2	To assess the reactivity patterns of enolates and their mechanisms	A, An	1,5
3	To synthesize molecules using popularly named reactions	A, C, S	1,5
4	To describe reaction mechanisms in terms of energetics, reaction kinetics, and thermodynamics	An, E	1,5
5	To predict suitable reaction conditions to carry out organic reactions	E, C, S	1,7

6	To have a thorough knowledge about catalysis by acids, bases and nucleophiles	U, I	1,7
7	To learn basic concepts of pericyclic reactions	U, I	1,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		**CO No.**
1	**Organic Reaction Mechanisms 2** Formation, structure and stability of carbanions; Reactions of carbanions: C-X bond (X = C, O, N) formations through the intermediary of carbanions. Chemistry of enolates and enamines. Aldol and Michael reactions, alkylation and acylation of enolates. Nucleophilic additions to carbonyls groups: Name reactions under carbanion chemistry-mechanism of Claisen, Dieckmann, Knoevenagel, Stobbe, Darzen and acyloin condensations, Shapiro reaction and Julia olefination. Favorskii rearrangement. Ylides: Chemistry of phosphorus and sulphur ylides - Wittig and related reactions, Peterson olefination. Formation, structure and stability of carbocations. Classical and non-classical carbocations. C-X bond (X = C, O, N) formations through the intermediary of carbocations. Molecular rearrangements including Wagner-Meerwein, Pinacol-pinacolone, Semipinacol, Dienone-phenol and Benzilic acid rearrangements, Noyori annulation, Prins reaction. C-C bond formation involving carbocations: Oxymercuration, Halolactonization.	**1,2**
2	**Named reactions in Organic Chemistry** Reimer-Tiemann, Cannizzaro, Mannich, Demjanov and Mitsunobu reactions, Aldol condensation, Robinson annulation Addition reactions: Addition of Grignard reagent, Michael addition Reduction reactions: Clemmensen, Wolf-Kishner, MPV Rearrangement reactions: Wolff, Hoffmann, Curtius, Lossen, Schmidt and Beckmann, Fries and Fischer-Hepp.	**3**
3	**Physical Organic Chemistry** Energy profiles, Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples, Linear free energy relationships-Hammet equation, Taft equation. Catalysis by acids, bases and nucleophiles with examples from acetal, cyanohydrin, Ester formation and hydrolysis reactions of esters - $A_{AC}2$, $A_{AC}1$, $A_{AL}1$, $B_{AC}2$ and $B_{AL}1$ mechanisms, Hard and soft acids, bases - HSAB principle and its applications (organic reactions only)	**4,5,6**

4	**Pericyclic reactions** Introduction to pericyclic reaction, Cycloaddition and Diels –Alder reactions, Electrocyclic reactions, Sigmatropic reactions, Chelotropic reactions. Thermal and photochemical pericyclic reactions, Conrotation and disrotation; Electrocyclic closure and opening in 4n and 4n+2 systems. Woodward-Hoffmann selection rules for electrocyclic reactions. Explanation for the mechanism of electrocyclic reactions and examples. Cycloaddition reactions: Suprafacial and antarafacial interactions. $2\pi + 2\pi$ and $4\pi + 2\pi$ cycloadditions. Diels-Alder reaction, Woodward-Hoffmann selection rules for cycloaddition reactions and examples. Mechanism by orbital symmetry correlation diagrams, Fukui Frontier Molecular Orbital (FMO) theory. Endo-exo selectivity in Diels-Alder reaction and its explanation by FMO theory. Sigmatropic reactions: mechanism of sigmatropic reactions, Cope and Claisen rearrangements	**7**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, Interactive instruction: Active co-operative, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanism, Academic Press, 2002.
2. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5thEdn., Springer, 2007.
3. J. March, M.B. Smith, March's Advanced Organic Chemistry: Reactions Mechanisms, and Structure, 6thEdn., Wiley, 2007.
4. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 2005.
5. Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, 1976.
6. R.T. Morrison, R.N. Boyd, S.K. Bhatacharjee, Organic Chemistry, 7thEdn., Pearson, 2011.
7. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.
8. L. Kuerti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.
9. Name Reactions in Heterocyclic Chemistry J. J.Li: Wiley interscience, 2005
10. N.S. Isaacs, Physical Organic Chemistry, ELBS/Longman, 1987.
11. S. Sankararaman, Pericyclic Reactions-A Textbook, Wiley VCH, 2005.
12. Organic Reaction Mechanisms Series Edited by Chris Knipe, ISBN 1935-0139, Published by Wiley 2018

Programme	Joint MSc
Course Name	Spectroscopic Methods in Chemistry
Type of Course	Core
Credit Value	4
Course Code	MGKUMPNSC39

Course Summary & Justification	Over the last few decades, spectroscopic techniques have grown into a vital instrument for chemical analysis, structure determination, and the study of dynamics in organic, inorganic, material science, and biological systems. Spectroscopic techniques are widely used to correctly investigate the chemical structure of an analyte. In each spectroscopic mathods (eg. UV-Vis, IR, microeave, NMR, Mass, ESR etc.) the electromagnetic radiation is allowed to interact with the molecule. The electric and magnetic property of the radiation is interacted with the atomic, molecular, and structural properties of the substance. Hence, the analyte is identified and characterized for the presence of atoms, bonds, functional groups, basic nucleus, nuclear spin, electron spin, molecular formula, and molecular weight.
Semester	II

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		60	40	0	40	140
Pre-requisite	Basic knowledge about the interaction of electromagnetic radiation with matter involving either absorption, emission, or scattering of radiation.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Elucidate the structure of an unknown organic compound using data from various spectroscopic techniques.	U, A	1,5
2	Basic principles of spectroscopy, interaction of electromagnetic radiation with matter, atomic and molecular spectroscopy	U	1

3	Selection rules and allowed transitions, factors effecting the molecular and electronic transitions	U, A	1
4	Different laws and principles like Beer-Lamberts Law, Frank-Condon principle, Woodward-Fieser rules, Raman Effect, Mössbuer effect etc	U, R	7
5	Understand the basics of UV-Visible spectroscopy Learn to derive structural information from the UV-Vis. Spectra of various molecules Understand the applications of this UV technique for various purposes.	U	1,7
6	Become aware of starching and banding of various bonds. Understand the role of Vibrational spectroscopy in functional group identification. Interpretation of organic and inorganic compounds using IR spectra. Characterization of various molecules.	U	6,7
7	Understand the role of Raman spectroscopic techniques for the characterization of materials Learn the applications of Raman spectroscopy.	U, A	6,7
8	Understand the basic principle of NMR spectroscopy, able to interpret the NMR spectrum of organic compounds.	U, An	1,6,7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		**CO No.**
1	**Foundations of Spectroscopic Techniques and Electronic Spectroscopy** Electromagnetic radiation, interaction of electromagnetic radiation with matter, Regions of the electromagnetic radiation, origin of spectrum, Jablonski diagram, intensity of absorption, transition probabilities, Born Oppenheimer approximation. Term symbols of diatomic molecules, selection rules, vibrational coarse structure and rotational fine structure of electronic spectrum, Franck-Condon principle, predissociation, Factors influencing the Electronic Spectroscopy. Application in uv-visible spectroscopy, Woodward-Fieser rules, calculation of heat of dissociation, Birge and Sponer method, electronic spectra of polyatomic molecules.	

2	**Infrared and Raman Spectroscopy** Morse potential energy diagram, fundamental vibrations, overtones and hot bands, determination of force constants, Factors influencing the vibrational frequency, Vibrations in simple molecules (H2O, CO2) and their symmetry notation for molecular vibrations – combined uses of IR and Raman spectroscopy in the structural elucidation of simple molecules. Vibrational spectra of polyatomic molecules, normal modes of vibrations, combination and difference bands, Fermi resonance, FT technique, introduction to FTIR spectroscopy, scattering of light, polarizability and classical theory of Raman spectrum, P, Q, R branches, rotational and vibrational Raman spectrum, complementarities of Raman and IR spectra, mutual exclusion principle, polarized and depolarized Raman lines, resonance Raman scattering and resonance fluorescence.	
3	**Microwave, ESR, and Mass Spectroscopy** Principal moments of inertia and classification (linear, symmetric tops, spherical tops and asymmetric tops), selection rules, intensity of rotational lines, relative population of energy levels, derivation of Jmax, effect of isotopic substitution, calculation of intermolecular distance, spectrum of non-rigid rotors, Rotational spectra of polyatomic molecules, linear and symmetric top molecules, Stark effect and its application, nuclear spin and electron spin interaction, chemical analysis by microwave spectroscopy. Elementary idea about Mass and ESR spectrometry, interpretation of data and solving problems with spectroscopic techniques.	
4	**NMR Spectroscopy:** 1H NMR, Spectral parameters – intensity, chemical shift, multiplicity, coupling constant, factors affecting chemical shift, characteristic chemical shifts of common organic compounds and functional groups. Analysis of first order and second – orderspectra – shift reagents – structure determination of organic compounds by 1H NMR spectra. Classification of molecules. (AB, ABX, AMX, ABC, A2B2 etc. types), spin decoupling. Chemical shifts and coupling constants (spin-spin coupling) involving different nuclei (1H, 13C). Combined problems of UV, IR and NMR Spectroscopy.	

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, Interactive instruction: Active co-operative, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. Banwell C. N.; McCash, E. M., Fundamentals of Molecular Spectroscopy, Tata McGraw Hill (2006).
2. Lampman, G. M.; Pavia, D. L.; Kriz, G. S.; Vyvyan, J.R., Spectroscopy, 4 th Ed., Cengage Learning (2010).
3. Drago, R. S., Physical Methods for Chemists, Saunders Company (1999).
4. Dyer, J. R., Applications of Spectroscopy of Organic Compounds, Prentice Hall (2004).
5. Kemp, W., Organic Spectroscopy, Macmillan (2011).
6. Aruldas, G., Molecular Structure and Spectroscopy, 2 nd Ed., Prentice Hall India (2001).
7. Nakamoto, K., Infrared and Raman Spectra of Inorganic and Coordination compounds, Wiley-Interscience, New York (2008).
8. Gunther, H., and NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry, 2 nd Ed., John Wiley & Sons (1995).
9. Viswanathan B.; Kannan S.; Deka, R. C., Catalysts and Surfaces Characterization Techniques, Narosa Publishers (2010).
10. D. H. Williams and I. Fleming, "Spectroscopic methods in organic chemistry," 6th Edition, Tata McGraw Hill, 2011
11. R.M. Silverstein, F.X. Webster, Spectrometric Identification of Organic Compounds, John Wiley Publications, 2009, 6th Edition
12. D. F. Taber, Organic Spectroscopic Structure Determination: A Problem Based Learning Approach, Oxford University Press, 2007.

Programme	Joint MSc					
Course Name	Nanomaterials and characterizations					
Type of Course	Core					
Course Code	MGKUMPNSC40					
Course Summary & Justification	This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of the various nanofabrication techniques, synthesis strategies, and different characterization techniques.					
Semester	II		Credit		3	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Basics of Nanochemistry.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Students will get an understanding of different Synthesis strategies; Bottom up and Top-down approaches. (Module 1)	U, A	1, 3, 7
2	Students will learn physical, chemical and biological characterization methods (Module 2)	U, A	1, 2, 7
3	Students will learn AFM, SEM, Deep UV and X-ray based lithography techniques (Module 3).	An, E	1, 2, 4
4	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 (Module 4)	E	1, 9
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Synthesis strategies** Bottom-up approaches- sol- gel technique-co-precipitation hydrolysis: sonochemical method- combustion technique- colloidal precipitation-template process-spinning- Chemical reduction Top-down approach: solid state sintering- grain growth-electric arc method-ion beam induced nanostructures- grinding-ball milling-control of grain size-Laser	1
2	**Module 2** **Physical, chemical and biological methods** Types of Nanomaterials: Carbon Nanotubes, Fullerene, Quantum dots, nanowire, nanocones, graphene and metal nanoparticles Inert gas condensation -RF plasma-Ion sputtering- laser ablation- laser pyrolysis-molecular beam epitaxy -chemical vapour deposition – electrode deposition- solvothermal synthesis -metal nanocrystals by reduction-arrested precipitation -photochemical synthesis-liquid -liquid interface-cluster compounds. Biological methods: use of bacterial fungi actinomycetes for nanoparticle synthesis, magneto tactic bacteria for natural synthesis of magnetic nanoparticles- mechanism of formation – role of plants in nanoparticle synthesis	2
3	**Module 3** **Lithographic techniques** AFM based nanolithography and nano manipulation, E beam lithography and SEM based nanolithography and nano manipulation, ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based graphy	3
4	**Module 4** **Characterization Techniques** X-ray diffractometry- fundamental of X-ray diffraction, powder diffraction method, small angle x-ray scattering and wide-angle x-ray scattering, quantitative determination of phase, strain and particle size, Scanning probe microscopy and scanning tunnelling microscopy- basic principle and instrumentation and application, Optical microscopy– SEM, TEM, AFM: operation principle, instrumentation and application, UV-Vis-NIR spectrometry and FTIR – basic principle	4

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, Interactive instruction: Active co-operative, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. Chemistry of nano materials: synthesis, properties and applications by C. N. R. Rao et, al, Wiley-VCH, 2004
2. Introduction to Nanoscience and Nanotechnology by K. K. Chattopadhyay and A. N. Banerjee, PHI Learning View All, 2009
3. Nanoparticle technology handbook by Masuo Hosokawa et. Al, Elsevier Science, 2007
4. Handbook of nanoscience, engineering- Goddard et. Al, CRC Press, 2012
5. Nanomaterials handbook -Yory Gogotsi, Taylor & Francis, 2006
6. Springer handbook of nanotechnology- Bharat Bhushan, 2004
7. Scanning probe microscopy: Analytical methods (nanoscience and technology)-Roland Wiesendanger, Springer, 1994
8. Advanced x-ray techniques in research and industries-A. K. Singh, New IOS Press Publication, 2005
9. X- ray diffraction procedures: for polycrystalline and amorphous materials, 2nd edition – Harold P. Klug, Leroy E Alexander, Wiley- Interscience, 1974
10. Transmission electron microscopy: A textbook for materials science (4- vol set)-David B. Williams and C. Barry carter, Springer, 2009
11. Introduction of X-ray crystallography-M. M. Woolfson, Cambridge University Press, 1970
12. Physical principles of electron microscopy: an introduction to TEM, SEM and AEM – Ray
13. F. Egerton, Springer, 2005
14. Nanomaterials Synthesis, Characterization, and Applications*Edited By A. K. Haghi, Ajesh K. Zachariah, Nandakumar Kalarikkal, ISBN*9781774632581Published by Apple Academic Press 2021
15. Handbook of Synthetic Methodologies and Protocols of NanomaterialsEditor-in-chief: Yadong Yin, ISBN: 978-981-3277-78-6 Published by World Scientiffic series in Nanoscience and Nanotechnology 2019

Programme	Joint MSc
Course Name	Practical III - Organic Chemistry
Type of Course	Core
Credit Value	2
Course Code	MGKUMPNSC41

Course Summary & Justification	This course is designed to give the student an awareness about the safety measures to be taken in the lab, familiarizing the different glassware and equipments used, separation of the components present in the given binary mixture organic compounds using appropriate separation methods and analyzing the separated components using standard procedures. Students will learn how to apply common laboratory techniques to determine the structure, reactivity and analysis of organic compounds. Preparation of different organic molecules from simple molecules is also included in the course. They will become familiar with the nomenclature and behavior of organic functional groups through reactions and instrumental analysis. Characterisation of organic compounds by means of spectroscopic methods (IR, NMR and UV-Visible) are also included. Students will also be taught tools such as ChemDraw / Chemsketch which will be very handy in their future studies and career.					
Semester	II					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
			40	40		80
Prerequisite	Basic knowledge in practical organic chemistry.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To handle organic chemicals, glassware and precautions to be taken for safety in a chemistry lab	R, U, A	1,5,7
2	To perform experiments individually and to gain knowledge about principles and techniques involved in various experiments	An, A, S, I	1,3
3	To evaluate the properties of synthesized compounds through spectroscopic and analytical data	E, An	1,4,6

4	To analyze the mechanisms of the reactions in the experiment performed	An, U, E, S	1,4,6
5	To characterize organic compounds by means of spectroscopic analysis techniques	R, U, A, An, S, Ap	4,6
6	To demonstrate organic reaction schemes using ChemDraw / Chemsketch	U, A, C, S, I, Ap	6
**Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

	CO No.
I. Multistep synthesis and characterization of organic compounds	**1,2**
II. Characterization of Compounds Infra-Red Spectroscopy NMR Spectroscopy UV-Visible Spectroscopy	**3**
II. Drawing the reaction schemes of the following reactions by ChemDraw, Symyx Draw and Chemsketch. **Condensation** 1. Dieckmann condensation 2. Claisen condensation 3. Darzen condensation 4. Aldol condensation **Oxidation / Reduction** 5. Ozonolysis 6. Baeyer Villiger oxidation 7. Cannizaro reaction 8. Clemmenson reduction **Rearrangement** 1. Benzilic acid rearrangement 2. Pinacol – Pinacolone rearrangement 3. Dienone – Phenol rearrangement 4. Wagner – Meerwein rearrangement **Pericyclic reaction** 1. Diels – Alder reaction **2.** Cope rearrangement	**4,5,6**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** Lab/Experiment skills Lab record/Report Viva-voce Lab Discipline (participation, punctuality, accuracy)

Programme	Joint MSc
Course Name	Practical IV - Physical Chemistry
Type of Course	Core
Credit Value	2
Course Code	MGKUMPNSC42

Course Summary & Justification	To have hand-on experiences of techniques for verifying physical and chemical properties					
Semester	II					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		0	40	40		80
Pre-requisite	Bachelors degree in chemistry, with physics and mathematics as subsidiaries.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To conduct the experiment on various instrumental techniques.	A	4,6
2	To measure various physical and chemical properties.	A	6
3	To describe the principles behind the experiment performed in the laboratory.	Ap	7
4	To interpret the experimental results obtained by various techniques.	An	6
5	To understand the principles behind the experiment performed in the laboratory.	U	7
6	The students will acquire knowledge of experimental techniques for controlling the chemical reactions.	C	2,7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

	CO No.
Module 1 **Surface Chemistry** • Study the adsorption of acetic acid by activated charcoal and verify the Langmuir and Freundlich adsorption isotherms. **Chemical Kinetics** • Study the kinetics of the acid-catalysed hydrolysis of methyl acetate and evaluate the value of the rate constant. • Evaluate the activation energy for the acid catalysed hydrolysis of methyl acetate. **Phase Equilibria** • Determine the transition temperature of the given salt hydrate.	**1,2,3,4,5,6**
Module 2 **Thermodynamic Properties of Solution** • Determine the partition coefficient for the distribution of succinic acid between water and 1-butanol. • Determination of partition coefficient of benzoic acid between toluene and water. **Conductometry** • Determination of cell constant • Verification of Onsager equation and determine the equivalent conductance at infinite dilution of strong electrolyte • Determine the concentration of the given strong acid by conductometric titration with a strong base	**1,2,3,4,5,6**
Module 3 **Optical Measurements in Chemistry** • Determine the refractive index of the given liquid by Abbe refractometer, and hence the specific and molar refraction • Determine the molar refractivity of water, methanol, acetic acid, ethyl acetate, 1,4-carbon tetrachloride and calculate the refraction equivalents of C, H, O and Cl. • Determine the specific, molecular and intrinsic rotations of the given optically active substance. • Determine the concentration of the unknown solution of the optically active compound by polarimetric measurements. • To study kinetics of inversion of cane sugar by optical rotation measurement.	**1,2,3,4,5,6**

Module 4 **Absorption Spectroscopy** • Verify the Beer-Lambert's law and determine the unknown concentration of a given solution. • Simultaneous estimation of manganese and chromium in a solution of dichromate and permanganate mixtures. • Study the effect of extended conjugation on the wave length of maximum absorption of organic compounds. • Characterize the given organic compounds by IR, and UV-vis. Spectroscopic techniques.	**1,2,3,4,5,6**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Interactive Instruction: Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion on the theoretical back ground of the experiments to be carried out. Presentation by individual student/ Group representative
Assessment Types	**Mode of Assessment** Continuous Internal Assessment (CIA) Experiments done in the laboratory and recording the results Seminar Presentation – theory of each experiment to be discussed and present in the seminar Attendance and punctuality Viva-voce examination

REFERENCES

1. Shoemaker, Garland and Steinfeld , Experiments in Physical Chemistry, Third Editon, , McGraw-Hill,1967.
2. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, BViva Books Pvt. Ltd., N. Delhi, 2005
3. J. B. Yadav, Advanced Practical Physical Chemistry, 29th edn., 2010, Krishna Prakashan Media Pvt. Ltd., Meerut.
4. R.C.Das and B. Behera ,Experimental Physical Chemistry, McGraw-Hill Education, 1984.
5. Haghi, A. K.; M., Praveen K.; Pai, Avinash R.; Thomas, Sabu, Theoretical models and experimental approaches in physical chemistry: research methodology and practical methods, Apple Academic Press Inc, 2019.

Programme	Joint MSc
Course Name	Chemical Bonding and Computational Chemistry
Type of Course	Elective
Course Code	MGKUMPNSE14

Course Summary & Justification	The learners should be able to apply, analyse and evaluate group theoretical concepts in spectroscopy, extent the ideas of quantum mechanics from one electron system to many electron systems and various theories of chemical bonding.					
Semester	II		Credit		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Quantum chemistry, Strong mathematical skill in Differential Equations and Linear Algebra.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand various approximation methods which includes variation theorem, perturbation method, Hartree Fock method etc.	U, A	1
2	Understand the quantum mechanical aspects of chemical bonding. Student will deeply learn about the Molecular orbital theory, hybridisation and Huckel Molecular orbital theory.	U, A	1,7
3	Understand the various aspects of computational chemistry such as Ab initio method, HF method, SCF method, Roothens theorem etc. Also, learners get a strong knowledge on various computer applications like GAMESS, Firefly etc.	An, E	7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Approximation Methods in Quantum Mechanics** Many-body problem and the need of approximation methods, independent particle model. Variation method: Variation theorem with proof, illustration of variation theorem using the trial function x(a-x) for particle in a 1D-box and using the trial function e-αr for the hydrogen atom, variation treatment for the ground state of helium atom. Perturbation method, time-independent perturbation method (non-degenerate case only), first order correction to energy and wave function, illustration by application to particle in a 1D-box with slanted bottom, perturbation treatment of the ground state of the helium atom. Qualitative idea of Hellmann-Feynman theorem. Hartree-Fock method, multi-electron atoms. Hartree-Fock equations (no derivation). The Fock operator, core 57amiltonian, coulomb operator and exchange operator. Qualitative treatment of Hartree-Fock Self-Consistent Field (HFSCF) method. Roothan's concept of basis functions, Slater type orbitals (STO) and Gaussian type orbitals (GTO), sketches of STO and GTO.	1
2	**Chemical Bonding** Schrödinger equation for molecules. Born-Oppenheimer approximation, valence bond (VB) theory, VB theory of H2 molecule, singlet and triplet state functions (spin orbitals) of H2. Molecular Orbital (MO) theory, MO theory of H2 + ion, MO theory of H2 molecule, MO treatment of homonuclear diatomic molecules Li2, Be2, N2, O2 and F2 and hetero nuclear diatomic molecules LiH, CO, NO and HF,bond order. Correlation diagrams, non-crossing rule, spectroscopic term symbols for diatomic molecules, comparison of MO and VB theories. Hybridization, quantum mechanical treatment of sp, sp2 and sp3 hybridisation. Semiempirical MO treatment of planar conjugated molecules, Hückel Molecular Orbital (HMO) theory of ethene, allyl systems, butadiene and benzene. Calculation of charge distributions, bond orders and free valency.	2

3	**Computational Quantum Chemistry** Introduction and scope of computational chemistry, potential energy surface, conformational search, global minimum, local minima, saddle points. Ab initio methods: A review of Hartee-Fock method, self-consistent field (SCF) procedure. Roothan concept basis functions. Basis sets and its classification: Slater type and Gaussian type basis sets, minimal basis set, Pople style basis sets. HartreeFock limit. Post Hartree-Fock methods – introduction to Møller Plesset perturbation theory, configuration interaction, coupled cluster and semi empirical methods. Introduction to Density Functional Theory (DFT) methods: Hohenberg-Kohn theorems, Kohn-Sham orbitals, exchange correlation functional, local density approximation, generalized gradient approximation, hybrid functionals (only the basic principles and terms need to be introduced). Comparison of ab initio, semi empirical and DFT methods. Molecular geometry input: Cartesian coordinates and internal coordinates, Z matrix, Z-matrix of single atom, diatomic molecule, non-linear triatomic molecule, linear triatomic molecule, polyatomic molecules like ammonia, methane and ethane. General format of GAMESS / Firefly input file, single point energy calculation, geometry optimization, constrained optimization and frequency calculation. Koopmans' theorem. Features of molecular mechanics force field-bond stretching, angle bending, torsional terms, non-bonded interactions and electrostatic interactions. Commonly used force fields- AMBER and CHARMM	**3**

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Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, Interactive instruction: Active co-operative, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. N. Levine, Quantum Chemistry, 7thEdn., Pearson Education Inc., 2016.
2. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4thEdn., Oxford University Press, 2005.
3. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
4. J.P. Lowe, K Peterson, Quantum Chemistry, 3rdEdn., Academic Press, 2006.
5. R. Anatharaman, Fundamentals of Quantum Chemistry, Macmillan India, 2001.

6. R.K. Prasad, Quantum Chemistry, 3rdEdn., New Age International, 2006.
7. T. Engel, Quantum Chemistry and Spectroscopy, Pearson Education, 2006.
8. H. Metiu, Physical Chemistry:Quantum Mechanics, Taylor & Francis, 2006.
9. L. Pauling, E.B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1935.
10. M.S. Pathania, Quantum Chemistry and Spectroscopy (Problems & Solutions), Vishal Publications, 1984.
11. K.I. Ramachandran, G. Deepa, K. Namboori, Computational Chemistry and Molecular Modeling: Principles and Applications, Springer, 2008.
12. Hinchliffe, Molecular Modelling for Beginners, 2ndEdn., John Wiley & Sons, 2008.
13. C.J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2ndEdn., John Wiley & Sons, 2004.
14. D.C. Young, Computational Chemistry: A Practical Guide for Applying Techniques to RealWorld Problems, John Wiley & Sons, 2001.

Programme	Joint MSc
Course Name	Nanoelectronics and electrochemistry
Type of Course	Elective
Course Code	MGKUMPNSE15

Course Summary & Justification	The students will be able to understand the basic concepts of nanoelectronic devices and nanotechnology. This course enables the learners to be capable of understanding the fundamentals of electrochemistry.					
Semester	II		Credit	4		
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Solid state devices, Semiconducting nanostructures, VLSI					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	understand the basic and advance concepts of nanoelectronics.	U	1, 5
2	understand the methods of fabrication of nano-layers	U	1, 5
3	Understand the basic principles of Electrochemistry	U	1, 3
4	Understand the working of 2 dimensional nanoelectronic system and basic nanoelectronic devices	U	1, 3
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Module 1** **Introduction to nanoelectronics:** Introduction to nanotechnology, Impacts, Limitations of conventional microelectronics, Trends in microelectronics and optoelectronics Mesoscopic physics, trends in microelectronics and optoelectronics, characteristic lengths in mesoscopic systems, Quantum mechanical coherence, Classification of Nano structures, Low dimensional structures Quantum wells, wires and dots, Density of states and dimensionality, Basic properties of two dimensional semiconductor nanostructures, square quantum wells of finite depth, parabolic and triangular quantum wells, Quantum wires and quantum dots, carbon nano tube, graphene	1
2	**Module 2** **Introduction to methods of fabrication of nano-layers**: Introduction to methods of fabrication of nano-layers, different approaches, physical vapour deposition, chemical vapour deposition, Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods, sol gel, self-assembly, precipitation of quantum dots. Molecular Beam Epitaxy, Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods	2
3	**Module 3** **Fundamentals of Electrochemistry:** Fundamental Equations - Nernst equation, Equilibrium constant, Mass-transfer limiting current, Cottrell equation, Faraday's law, Equations governing modes of mass transfer - Nernst–Planck equation, Fick's laws of diffusion, General cell designs, Electrochemical cells and its applications. Electrochemical cells, concentration cells and activity coefficient determination, liquid,Fuel cells- Theory and working of fuel cells- methanol fuel cell, H2-O2 fuel cell and solid oxide fuel cells, Corrosion and methods of prevention, Pourbaix diagram and Evans diagrams.	3
4	**Module 4** **Two-dimensional nano electronic system:** Two-dimensional behaviour, MOSFET structures, Heterojunctions. Transport of charge in Nanostructures under Electric field - parallel transport, hot electrons, perpendicular transport. Quantum transport in nanostructures, Coulomb blockade. Transport of charge in magnetic field - Effect of magnetic field on a crystal. Aharonov-Bohm effect, the Shubnikov-de Hass effect, the quantum Hall effect.The concept of super lattices Kronig - Penney model of super lattice.	4
5	**Module 5** **Nanoelectronic devices:** MODFETS, heterojunction bipolar transistors, Resonant tunnel effect, RTD, RTT, Hot electron transistors,Coulomb blockade effect and single electron transistor, CNT transistors,Heterostructure semiconductor laser,Quantum well laser, quantum dot LED, quantum dot laser, Quantum well optical modulator, quantum well sub band photo detectors, principle of NEMS	1

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, Interactive instruction: Active co-operative, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. Chattopadhyay, Banerjee, Introduction to Nanoscience & Technology, PHI, 2012
2. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
3. K. Goser, P. Glosekotter, J. Dienstuhl, Nanoelectronics and nanosystems, Springer 2004.
4. Murty, Shankar, Text book of Nanoscience and Nanotechnology, Universities Press,2012.
5. Poole, Introduction to Nanotechnology, John Wiley, 2006.
6. Supriyo Dutta, Quantum Transport- Atom to transistor, Cambridge, 2013.
7. S. Glasstone, Introduction to Electrochemistry, Biblio Bazar, 2011
8. R. Crow, Principles and Applications of Electrochemistry, 4th Edn., S. Thornes, 1994.
9. K. Sharma, Electrochemistry, Krisna Prakashan, 1985
10. John O'M Bockris and Amulya K. N. Reddy, Modern Electrochemistry Vol I & II Springer International Edn.,
11. Loutfy H. Madkour, Nanoelectronic Materials: Fundamentals and Applications, Springer, 2019.
12. Vinod Kumar Khanna, Integrated Nanoelectronics, Springer, 2016.
13. Brajesh Kumar Kaushik, Nanoelectronics, Elsevier, 2018.
14. John O'm. Bockris And Amulya K.N Reddy, Modern Electrochemistry 2Ed Vol 2A Fundamentals of Electrodics, Springer India , 2018.
15. Chatterjee Sananda, Introduction to Electrochemistry, Discovery Publishing House Pvt Ltd, 2020.

Programme	Joint MSc					
Course Name	**Industrial Internship**					
Course Credit	**2**					
Type of Course	**CORE**					
Course Code	MGKUMPNSC43					
Course Summary & Justification	The candidate shall do an industrial visit in any of the research institute.					
Semester	**4**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Library work, lab work, Team work, independent learning	-	-	-	-	-
Pre-requisite						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course the students are expected to		
	To clearly present and discuss the research objectives, methodology, analysis, results and conclusions effectively.	A	2, 3, 4, 5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Gain deeper knowledge of methods in the topic of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6
7	Create, analyse and critically evaluate different problems and their solutions.	C	7
8	Gain a consciousness of the ethical aspects of research.	E	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, , Library work, laboratory work, Team work, independent learning and Group discussion, Presentation of research work.
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners.

SEMESTER III

Programme	Joint MSc
Course Name	Advanced Synthetic Organic Chemistry
Type of Course	Core
Credit Value	4
Course Code	MGKUMPNSC44

Course Summary & Justification	The course describes different types of advanced organic reactions and reagents as tools for the synthesis of organic compounds. Principles of protecting group chemistry and retrosynthetic approach towards organic synthesis are also dealt with. Analysis and interpretation of molecular recognition and supramolecular chemistry are also aimed at, along with the understanding of basic principles of green chemistry. The course also aims at acquainting students with the role of reagents and catalysts in organic synthesis.					
Semester	III					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		60	40	0	40	140
Prerequisite	Knowledge in oxidation and reduction reactions in organic chemistry. Fundamental understanding of green chemistry.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To apply the basic oxidation and reduction reactions on organic molecules	U, A	1,5
2	To describe protective groups in organic synthesis	U, I	1,5
3	To equip the students to synthesize complex natural and unnatural compounds of importance by practicing retrosynthetic analysis	A, C, S	1,5
4	To analyse the difference in the basic types of synthetic approaches	An, E	1,5
5	To understand the fundamentals of supramolecular chemistry	U, I	1,5
6	To distinguish and synthesize cation, anion and neutral molecule binding host molecules	U, A, C	1,5
7	To demonstrate the applications of supramolecular chemistry	U, Ap	1,5
8	To understand green chemistry and sustainability developments that affect society, environment and economic development	I, Ap	1,5
9	To analyse and compare chemical/industrial processes based on their relative "greenness"	An, E, S	1,5
10	To understand the role of reagents and catalysts in organic synthesis	U, I	7

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

Module No.		CO No.
1	**Module 1: Organic Synthesis via Oxidation and Reduction** Metal based and non-metal-based oxidations of Alcohols to carbonyls Chromium based reagents (John's oxidation, Collin's oxidation, Sarrett oxidation) Manganese, aluminium and DMSO based reagents (Swern oxidation, Moffatt–Pfitzner oxidation, Kornblum oxidation, Corey-Kim oxidation) Alkenes to epoxides (peroxides/peracids based) - Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation Alkenes to diols (manganese and osmium based) - Prevost reaction and Woodward modification Alkenes to carbonyls with bond cleavage (manganese based, ozonolysis) Alkenes to alcohols/carbonyls without bond cleavage – hydroboration - oxidation, Wacker oxidation, selenium based allylic oxidation Ketones to ester/lactones – Baeyer -Villiger oxidation Catalytic hydrogenation Heterogeneous: Palladium/Platinum/Rhodium and Nickel Homogeneous: Wilkinson Metal based reductions: Birch reduction, pinacol formation, acyloin formation Enzymatic reduction using Baker's yeast	**1**
2	**Module 2: Modern Reagents and Retrosynthetic Analysis** Reagents in organic synthesis: Metal hydride reductions using $NaBH_4$, $LiAlH_4$, DIBAL, K-selectride, Sodium cyanoborohydride, Lithium diisopropylamide (LDA), Dicyclohexyl Carbodiimide (DCC), Gilman's reagent, DDQ Protecting group chemistry: Protection, activation and deprotection process in organic synthesis, protection and deprotection of hydroxyl, carboxyl, carbonyl and amino groups. Retrosynthetic analysis: Basic principles and terminology, Synthesis of aromatic compounds, One group and two group C-X disconnections, One group C-C and two group C-C disconnections. Retrosynthesis of D-luciferin, Functional equivalents and reactivity – Umpolung / polarity inversion reaction (Ireland-Claisen rearrangement).	**2,3,4**
3	**Module 3: Advances in Organic Chemistry** Supramolecular Chemistry: Introduction to supramolecular chemistry: Host, Guest, Host-Guest complex, Lock and key principle, Preorganisation, Complementarity. Cation binding hosts (Crown ethers, Podands, Calixarenes), Anion binding hosts (Cyclophanes), Naturally occurring cyclic host (Cyclodextrin), Molecular clefts and tweezers, Macrocyclic polyamines (Nitrogen based cyclic hosts), Naturally occurring Siderophores, Rhodopsin – A Supramolecular photonic device. Introduction to Green Chemistry: Twelve principles of Green Chemistry. Green Solvents: Ionic liquids, supercritical CO_2, fluorous	**5,6,7,8,9**

	solvents, PEG. Green Alternatives to Organic Synthesis (Microwave assisted and Sonochemical synthesis) with examples (Synthesis of adipic acid from cyclohexene, synthesis of Ibuprofen).	
4	**Module 4: Catalysis in Organic Chemistry** Baylis-Hillman reaction, Henry reaction, Nef reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction. Brook rearrangement. Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki-Miyaura, Negishi, Sonogashira, Nozaki-Hiyama-Kishi, Buchwald-Hartwig, Ullmann and Glaser coupling reactions. Click reactions (Huisgen 1,3-dipolar addition). Ugireaction, Passerini reaction and Biginelli reaction.	**10**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Active co-operative learning, Library work, E-learning Group discussion, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Internal Test – Objective and descriptive answer type b. Submitting assignments c. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES

1. M.B. Smith, Organic Synthesis, 3rdEdn., Wavefunction Inc., 2010.
2. J. Clayden, N. Greeves, S. Warren,P. Wothers, Organic Chemistry, Oxford University Press, 2001.
3. F.A. Carey, R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5thEdn., Springer, 2007.
4. S. Warren, P. Wyatt, Organic Synthesis: The Disconnection Approach, 2ndEdn., Wiley, 2008.
5. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, 4thEdn., Cambridge University Press, 2004.
6. R.O.C. Norman, J.M. Coxon, Principles of Organic Synthesis, 3rdEdn., Chapmann and Hall, 1993.
7. www.arkat-usa.org(Retrosynthesis of D-luciferin).
8. J.M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, VCH, 1995.
9. F. Vogtle, Supramolecular Chemistry: An Introduction, Wiley, 1993.
10. V.K. Ahluwalia, Green Chemistry, Ane Books, 2009.
11. V.K. Ahluwalia, Green Chemistry, Narosa Publishing House, 2013
12. L. Kuerti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.
13. George S. Zweifel, Michael H. Nantz, Peter Somfai, Modern Organic Synthesis: An Introduction, Wiley, 2017.
14. Dennis G. Morrell, Catalysis of Organic Reactions, CRC Press, 2019.

15. Nandkishor Chandan, Advanced Organic Synthesis, Mahi Publication, 2021

Programme	Joint MSc
Course Name	Physical Chemistry -II
Type of Course	Core
Credit Value	4
Course Code	MGKUMPNSC45

Course Summary & Justification	The course describes different types of advanced organic reactions and reagents as tools for the synthesis of organic compounds. Principles of protecting group chemistry and retrosynthetic approach towards organic synthesis are also dealt with. Analysis and interpretation of molecular recognition and supramolecular chemistry are also aimed at, along with the understanding of basic principles of green chemistry. The course also aims at acquainting students with the role of reagents and catalysts in organic synthesis.					
Semester	III					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		60	40	0	40	140
Prerequisite	Knowledge in solid state chemistry, thermodynamics and electrochemistry (Graduate level).					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1.	Understanding of advanced concepts of thermodynamics	U, A	1,5
2.	Illustrates application of pahse rule to three component syatems.		1,5
3	Describes general principles and classification preparation of solids	U	1,5
4	Describe the importance and properties of defects in solid	U,A	1,5
5	Describe the free election , band theories of solids	U,R	1,5
6	Illustrate the optical , magnetic and electrical properties of solids	U	1,5
7	Design and development of solid materials with pre-required properties based on the structure of solids.	U	1,5

8	Analyze the physical-chemical ,unique optical, electrical, magnetic, thermal, and mechanical properties of solids.	U,A	7
9	Understanding and analysis of advanced electrochemistry	U, R	7
10	Introduced machine learning approaches in nanoscience	U, I, A	2,3,4
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		**CO No.**
1	**Thermodynamics II** Fugacity: Relation between fugacity and pressure, determination of fugacity of gases. Variation of fugacity with temperature and pressure. Activity and activity coefficients. Variation of activity with temperature and pressure. Determination of activity coefficients by electrical methods. Thermodynamics of dilute solutions: Raoult's law, Henry's law. Ideal and non-ideal solutions. Discussion and thermodynamic derivation of the laws of osmotic pressure, cryoscopy and ebullioscopy. Determination of molecular weights. Thermodynamic treatment using the concept of chemical potentials. Phase Rule Studies: Thermodynamic derivation of phase rule; application of phase rule to the two component systems: simple eutectic type, compound formation with congruent melting point and incongruent melting points, systems involving the formation of a continuous series of solid solutions. Application of phase rule to three component systems: Systems of three liquids and systems of two salts and a liquid.	**1,2**
2	**Solids State and Advanced Materials** Structure – Types and classification of solids, distinction between crystalline and amorphous solids. Unit cell, Bravais lattice, symmetry elements, Miller indices, Bragg's law. Classification of crystals based on bond type and packing in crystals. Imperfections in crystals – Types of defects, stoichiometric defects – Schotky and Frenkel. Non-stoichiometric defects – Metal excess and metal deficient, consequences of metal deficiency defects. Inorganic crystals – Coordination number, radius ratio rule and shapes of ionic crystals. Structure of Pervoskite, spinels and inverse spinels, structures of ionic crystals – AX type: CsCl, ZnS (Zinc blende, Wurtzite), AX2 type: CaF2, TiO2 , Cd2. Experimental methods of crystal structure determination: X - ray diffraction, electron diffraction and neutron diffraction. Comparative study of the three diffraction methods. Electrical, Magnetic and Optical Properties: Band theory of solids, significance of band gap, conductors, semi-conductors and insulators. Electrical & optical properties: Electrical conduction in metals. Super conductivity, origin of superconductivity, type I and type II superconductors, meisner effect, Bardeen, Cooper and Schriefer (BCS) theory, Cooper pairs. High temperature superconductors, super conducting cuprates - YBaCu oxide system. Josephson's Junction, conventional superconductors, organic superconductors. Electrical properties: thermoelectric effects, Thomson effects, Peltier effect, seebeck effect, thermocouples, Hall Effect.	**3,4,5,6,7**

	Magnetic properties: Origin of magnetic dipoles in solids, ferrimagnetic materials, spontaneous magnetization. Dielectric materials, ferro, pyro, piezo electricity and their relations, applications.	
3	**Electrochemistry and Electromotive Force** Theories of ions in solution, Drude and Nernst's electrostriction model and Born's model, Debye-Huckel theory, derivation of Debye-Huckel-Onsager equation, validity of DHO equation for aqueous and non-aqueous solutions, Debye-Falkenhagen effect, conductance with high potential gradients, activity and activity coefficients in electrolytic solutions, ionic strength, Debye-Huckel limiting law and its various forms, qualitative and quantitative tests of Debye-Huckel limiting equation, deviations from the DHLL, ion association, triple ions and conductance minima. Electrochemical cells, concentration cells and activity coefficient determination, liquid junction potential, evaluation of thermodynamic properties, the electrode double layer, electrode-electrolyte interface, different models of double layer, theory of multilayer capacity, electro capillary, Lippmann equation, membrane potential. Fuel cells- Theory and working of fuel cells- methanol fuel cell, H_2-O_2 fuel cell and solid oxide fuel cells. Corrosion and methods of prevention, Pourbaix diagram and Evans diagrams. Overvoltage: hydrogen and oxygen overvoltage, theories of overvoltage, Tafel equation and its significance, Butler-Volmer equation for simple electron transfer reactions, transfer coefficient, exchange current density, rate constants.	**8,9**
4	**Machine learning in Nanoscience** Introduction – workflow, Data preprocessing and feature engineering. Basic ML Algorithms – Regression analysis, Naïve Bayes classifiers, Support vector machine (SVM), Decision tree and random forest, Artificial neural network (ANN), Deep learning. Cross-validation. The theoretical basis of assisting DFT with ML. Machine Learning to Analyze Large Data Sets- Analysis of Spectra, Images, and Biological Outcomes, Deconvoluting Components in Mixed Signals, Machine Learning for Metrology of Nanoelectronics. Machine Learning for Design and Discovery- Inverse Design and Adversarial Networks in Nanophotonics, Active Learning, Automated Experimentation, Prediction of new 2D Materials and Heterostructures, Nanoscience to Advance Hardware for Machine Learning, Challenges and Opportunities for Machine Learning and Nanoscience.	**10**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Active co-operative learning, Library work, E-learning Group discussion, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Internal Test – Objective and descriptive answer type b. Submitting assignments c. Seminar Presentation – select a topic of choice in the

	concerned area and present in the seminar B. Semester End examination

REFERENCES

1. F. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press, 2009.
2. P. Atkins and J. Paula, Physical Chemistry, 10th Edition, Oxford University Press, Oxford 2014.
3. A. McQuarrie and J. D. Simon, Molecular Thermodynamics, University Science Books, California 2004
4. R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry, 2nd Edition, Oxford University Press, Oxford, 2007
5. A. McQuarrie, Statistical Mechanics, University Science Books, California 2005
6. Widom, Statistical Mechanics - A Concise Introduction for Chemists, Cambridge, University Press, 2002
7. Reif, Fundamentals of Statistical and Thermal Physics, Waveland Press, 2009.
8. P. Atkins and J. Paula, Physical Chemistry, 10th Edition, Oxford University Press, Oxford 2014
9. R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry, 2nd Edition, Oxford University Press, Oxford, 2007
10. A. McQuarrie, Statistical Mechanics, University Science Books, California 2005
11. Widom, Statistical Mechanics - A Concise Introduction for Chemists, Cambridge, University Press, 2002
12. A.R. West, Solid State Chemistry and its Applications, John Wiley and Sons, 2003.
13. F.A.Cotton, G.Wilkinson and P.Gaus – Basic Inorganic Chemistry, 3rd Edn. John Wiley and Sons 2003.
14. W.E. Addison, Structural Principles in Inorganic Chemistry, Longman.1961.
15. M. Adams, Inorganic Solids, John Wiley Sons.1974.
16. Kittel, Introduction to Solid State Physics, Wiley and Sons, 8th edition, 2004.
17. R. J. Silbey, R. A. Alberty, M. G. Bawendi, Physical Chemistry, 4th Edn., Wiley, 2005.
18. M. Barrow, Physical Chemistry, 5th Edn., Tata McGraw Hill, 2007.
19. K. J. Laidler, J. H. Meiser, B.C. Sanctuary, Physical Chemistry, 4th Edn., Houghton Mifflin, 2003.
20. P. W. Atkins, Physical Chemistry, ELBS, 1994.
21. W. Castellan, Physical Chemistry, Addison-Wesley, 1983.
22. S. Glasstone, Introduction to Electrochemistry, Biblio Bazar, 2011.
23. R. Crow, Principles and Applications of Electrochemistry, 4th Edn., S.Thornes, 1994.
24. K. Sharma, Electrochemistry, Krisna Prakashan, 1985.
25. John O'M Bockris and Amulya K.N. Reddy, Modern Electrochemistry Vol I & II Springer International Edn.2006.
26. Tim Allen, Machine Learning in Chemistry: The Impact of Artificial Intelligence, Theoretical and Computational Chemistry Series: Volume 17 [1 ed.]. 2020.

Programme	Joint MSc
Course Name	Application of Nanomaterials
Type of Course	Core
Credit Value	3
Course Code	MGKUMPNSC46

Course Summary & Justification	This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of the various application of nanomaterials in the field of medicine, agriculture, food, textile, defence, aerospace etc.					
Semester	III		Credit			
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Strong background in basic quantum mechanics and condensed matter physics.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Understand the applications of nanotechnology in medical field	U, A	2, 5
2	Student will learn about the applications of nanotechnology in the field of agriculture and food sector	U, A	2, 5
3	Understand the importance of nanotechnology in textile and cosmetics sector	A, E	5, 7
4	Understand the applications of nanotechnology in defence and aerospace field.	A, E	5, 7

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

Module No.		**CO No.**
1	**Biomedical Applications** Nanoparticles and Micro–organism- Biosensors- Bioreceptors and their properties – Biochips- Integrated nanosensor networks for detection and response- DNA based biosensors and diagnostics- Natural nanocomposite systems; spider silk, bones, shells – Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis –Tissue Engineering – Neuroscience -Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy – Protein Engineering Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.	**1**
2	**Agricultural and Food Sector Applications** Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing – Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- -Information and communication technology- Sensors- RF identification- Food safety- Nanomaterial based Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers	**2**

3	**Applications in Textile and Cosmetics Sector** Nanofiber production – Electrospinning and charge injection method – morphological control- yarns and polymide nanofibers- Carbon Nanotube and Nanofiber Reinforced Polymer Fibres- multifunctional polymer nanocomposites- Improvement of polymer functionality- Nylon-6 nanocomposites from polymerization- Dyeable Polypropylene – nanocoatings and surface modifications – Nano-filled polypropylene fibers – UV resistant, antibacterial, self-cleaning, flame retardant textiles – Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, cleaner kids clothes, Wired and Ready to Wear textiles- Cosmetics; Formulation of Gels, Shampoos, Hair-conditioners– Nanomaterials in Sun-screen UV protection – Colour cosmetics	**3**
4	**Defence and Aerospace Applications** Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre-exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.	**4**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar b. Assignments B. Semester End examination

REFERENCES /COMPULSORY READINGS

1. Mark. A, Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson, 2003.
2. Bharat Bhushan, "Springer Handbook of Nanotechnology", Barnes & Noble 2004.
3. Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.
4. Udo. H, Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers 2010.
5. Jennifer Kuzma and Peter Ver Hage, "Nanotechnology in agriculture and food production", Woodrow Wilson International Center, 2006.
6. Lynn. J, Frewer, Willehm Norde. R. H, Fischer and Kampers. W. H "Nanotechnology in the Agri- food sector", Wiley-VCH Verlag, 2011.
7. Brown. P. J and Stevens. K "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007.
8. Mai. Y-W "Polymer Nano composites", Woodhead publishing, 2006.
9. Chang. W.N "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.
10. Helvajian. H and. Robinson. E.Y "micro and nanotechnology for space systems" the aerospace corporation, Micrograph , 1997.
11. Margaret. E, Kosal, "Nanotechnology for Chemical and Biological defence, Springer 2009.

Programme	Joint MSc
Course Name	**Practical V - Synthesis of Nanomaterials**
Type of Course	**Practical**
Credit Value	2
Course Code	MGKUMPNSC47

Course Name	Synthesis of different Nanomaterials.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		0	40	40		80
Pre-requisite	Basic knowledge in practical chemistry (Undergraduate level).					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To Acquire sound knowledge about the fundamentals and importance of Nanomaterials.	R, U, An	3,4,5
2	To compare and correlate various Nanomaterials synthesis techniques.	U, A, An	1,3,4,5,6,7
3	To learn the handling of different chemicals (for nanomaterial synthesis), glassware, and precautions to be taken for safety in a chemistry lab	R, U, A	3,4,5
4	To learn the synthesis of different nanomaterials (bio-based nanomaterials, green synthesis of nanomaterials, etc.)	U, A, An, S	4,5
5	To perform experiments individually and to gain knowledge about principles and techniques involved in various experiments (nanomaterial synthesis)	An, A, S, I	5,6,7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Module 1** Extraction of Nanocellulose, Extraction of Nanochitin, Synthesis of different sized Ag nanoparticles by aqueous method, Synthesis of different sized Au nanoparticles by aqueous method, Chemical synthesis of CdSe Quantum dots with different sizes.	**1,2,3,4, 5**
2	**Module 2** Sol-gel synthesis of ZnO nanoparticles, Green synthesis of ZnO nanoparticles, Coprecipitation synthesis of magnetic (iron oxide) nanoparticles, Synthesis of metal oxide nanotubes, Hydro/Solvothermal synthesis of metal oxide nanostructures of different morphology by varying parameters, Synthesis of SnO_2 nanostructures, Hydrothermal synthesis of TiO2 nanoparticles, Synthesis of Graphene and Graphene Oxide, Synthesis of nanosilica.	**1,2,3,4, 5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** **A.** Lab/Experiment skills **B.** Lab record/Report **C.** Viva-voce **D.** Lab Discipline (participation, punctuality, accuracy) **E. Semester End examination**

REFERENCES

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao, Imperial college Press, (2006).
2. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), ISBN-13: 978-3527294435 . 1998.
3. Nanomaterials and Nanochemistry by C. Brechignac.P. Houdy M. Lahmani, Springer-Verlag 2007. (For Unit III-Part I Chapter I), 2007.
4. PADINJAKKARA A, Scarinzi G, Santagata G, Malinconico M, Razal JM, Thomas S, Salim NV. Enhancement of Adhesive Strength of Epoxy/Carboxyl-Terminated Poly(butadiene-co-acrylonitrile) Nanocomposites Using Waste Hemp Fiber-Derived Cellulose Nanofibers. ACS Industrial & Engineering Chemistry Research. 59, 23, 10904-10913. 2020.

Programme	Joint MSc
Course Name	Practical VI - Characterization of Nanomaterials
Type of Course	Practical
Credit Value	2
Course Code	MGKUMPNSC48

Course Summary & Justification	Characterization of different nanomaterials					
Semester	III					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		0	40	40		80
Pre-requisite	Basic knowledge in practical chemistry (Undergraduate level).					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To acquire sound knowledge about the fundamentals and importance of different characterization techniques (chemical, morphological, thermal, electrical etc.) for nanomaterials.	R, U, An	2,3,4,6,7
2	To compare and correlate various characterization techniques for nanomaterials.	U, A, An	4,7
3	To learn the handling of different characterization techniques for nanomaterials and precautions to be taken for safety.	R, U, A	2,3,4,6,7
4	To learn the basic/ working principle of different characterization techniques for nanomaterials.	U, A, An, S	2,3,4,6,7
5	To perform experiments (characterizations) individually and to gain knowledge about instrument operation and analysing of data.	An, A, S, I, Ap	2,3,4,6,7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

CO No.		Module
1	Studies of (synthesized) different nanomaterials using: Optical microscope, Scanning electron microscope, transmission electron microscope, confocal laser scanning microscopy, and atomic force microscope. Studies of different nanomaterials using X-ray diffraction, UV-visible spectroscopy, FT-IR spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Raman spectroscopy, Absorption and emission Spectroscopy.	**1,2,3,4,5**
2	Characterization of different nanomaterials using: Thermogravimetric analyser (TGA), Differential Scanning Calorimetry (DSC), and Vibrating sample magnetometer.	**1,2,3,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** A. Lab/Experiment skills B. Lab record/Report C. Viva-voce D. Lab Discipline (participation, punctuality, accuracy) E. Semester End examination

REFERENCES

1. Introduction to Nanoscience and Nanotechnology, by K K Chattopadhyay, PHI Learning Pvt. Ltd. New Delhi, ISBN-13: 978-81-203-3608-7. 2019.
2. Characterization of Materials Vol 1 &2, by Elton N. Kaufmann, John Wiley and Sons Publication. New Jersey. 2003.
3. Principles of instrumental analysis, Douglas A Skoog, Donald M West, Saunders College, Philadelphia. Publisher: Cengage; 6 edition ISBN-13: 978-81-315- 25579. 2014.
4. NANO: The Essentials- Understanding Nanoscience and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-9

5. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander, Publisher: Wiley-Blackwell; 2nd Revised edition edition (1 January 1974) ISBN-13: 978-0471493693

6. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter, Publisher: Springer; 1st ed. 1996. Corr. 6th printing edition (15 April 2005) ISBN-13: 978-0306453243

7. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton, Publisher: Springer; Softcover reprint of hardcover 1st ed. 2005 edition (12 October 2010) ISBN-13: 978-1441938374

8. Springer handbook of Nanotechnology ed. Bharat Bhushan (Springer), Publisher: Springer-Verlag (15 May 2006) ISBN-13: 978-3540343660

9. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435

Programme	Joint MSc
Course Name	Chemistry of Natural Products
Type of Course	Elective
Credit Value	4
Course Code	MGKUMPNSE16

Course Summary & Justification	Learning this course will provide a strong foundation in natural products such as carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Also provide knowledge about biogenesis of terpenoids and alkaloids. Students will be able to study the synthesis of a series of constituents such as camphor, atropine, papaverine, quinine, cyanin, quercetin, β-carotene, testosterone along with biosynthesis of PGE2 and PGF2α, structure of proteins, nucleic acids and methods for primary structure determination of peptides. This course aims to impart basic knowledge on the replication of DNA, flow of genetic information, protein biosynthesis, transcription and translation, genetic code, regulation of gene expression, DNA sequencing, The Human Genome Project, DNA profiling and the Polymerase Chain Reaction (PCR).
Semester	III

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning, collaborative learning, independent learning	60	40	0	40	140
Pre-requisite	Basic knowledge about natural products and DNA					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	The student should be able to understand the natural products such as carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids.	U	1,5
2	Understand the biogenesis of terpenoids and alkaloids	U,A	1,5

3	Gather information about to the synthesis of a series of constituents such as camphor, atropine, papaverine, quinine, cyanin, quercetin, β-carotene, testosterone along with biosynthesis of PGE2 and PGF2α, structure of proteins, nucleic acids and methods for primary structure determination of peptides.	U,R	1,5
4	Understand basic knowledge on the replication of DNA, flow of genetic information, protein biosynthesis, transcription and translation, genetic code, regulation of gene expression	U	1,5
5	Able to understand DNA sequencing, The Human Genome Project, DNA profiling and the Polymerase Chain Reaction (PCR).	U,A	7
6	Able to understand different classifications and nutritional values of lipids	U	1,5
7	Study the chemical properties of fatty acids and its reactivity towards various reagents	U	1,5
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module		**CO No.**
1	Natural products, Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids, Biogenesis of terpenoids and alkaloids.	**1**
2	Syntheis: Synthesis of camphor, atropine, papaverine, quinine, cyanin, quercetin, β-carotene, testosterone, biosynthesis of PGE2 and PGF2α, 5. 3 Structure of proteins, nucleic acids and methods for primary structure determination of peptides (N-terminal - Sanger's method and Edmond's method; C-terminal - Akabora method and carboxy peptidase method).	**2,3**
3	Replication of DNA, flow of genetic information, protein biosynthesis, transcription and translation, genetic code, regulation of gene expression, DNA sequencing, The Human Genome Project, DNA profiling and the Polymerase Chain Reaction (PCR).	**4,5**
4	**Lipids** Classification of lipids – Sources and classification of oils and fats, nomenclature of triglycerides. Nutritional functions of fats and oils, Caloric and non-caloric functions, Non nutritional functions of edible fats.	**6**

5	**Physical and Chemical Properties of Fatty acids** Physical properties of fatty acids: Crystal properties, thermal properties and spectral properties Chemical properties: Salt formation, esterification, hydrogenation, oxidation using various oxidising agents like potassium permanganate, ozone, peroxide, chromic acid, periodic acid, lead tetra acetate. Halogenation and addition reaction to double bonds.	**7**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Surprise test b. Internal Test – Objective and descriptive answer type c. Submitting assignments d. Seminar Presentation – select a topic of choice in the concerned area and present in the seminar B. Semester End examination

REFERENCES:

1. L Finar, Organic Chemistry, Volume 2: Stereochemistry and The Chemistry Natural Products, 5/E
2. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 2004
3. A.L. Lehninger, D.L. Nelson, M.M. Cox, Lehninger Principles of Biochemistry, 5 th Edn., W.H. Freeman, 2008
4. S.V. Bhat, B.A. Nagasampagi, M. Sivakumar, Chemistry of Natural Products, Narosa, 2005
5. Introduction to Natural Products Chemistry, *Edited By Rensheng Xu, Yang Ye,, Weimin Zhao; ISBN 9781439860762, Published by CRC Press, 2011*
6. Chemistry of Natural Products, by Sujata V. Bhat, B.A. Nagasampagi, Meenakshi Sivakumar; Published by Springer, 2005.
7. Chemistry of Biomolecules, Second Edition, By S. P. Bhutani; ISBN 9781032337951, Published by CRC Press, 2020
8. Biochemistry, 4th Edition, Donald Voet, Judith G. Voet; ISBN: 978-0-470-57095-1; Published by Wiley, 2010
9. General, Organic, and Biochemistry - 9th edition, by Katherine J. Denniston, Joseph J. Topping and Danae Quirk Dorr; ISBN13: 9780078021541, ISBN10: 0078021545; Published by McGraw-Hill Publishing Company, 2017.

Programme	Joint MSc					
Course Name	Nanomedicine and Drug Delivery System					
Type of Course	Elective					
Course Code	MGKUMPNSE17					
Course Summary & Justification	This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of the various application of nanomaterials in the field of medicine.					
Semester	III		Credit		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Strong background in basic quantum mechanics and condensed matter physics.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand the history of nano medicine	U, A	2, 5
2	Learn about various sensors and its applications	U, A	2, 5
3	Understand the basics of nano drug delivery systems	A, E	5, 7
4	Understand about various nano drug carriers and nanocarriers targeting different parts of body also about the role of nanocarriers in treatment and imaging of infections.	A, E	5, 7
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	**Prospect of Nano-Medicine** History of the idea – The Biological and Mechanical Traditions – Nano-medicine - Taxonomy – Bio-Pharmaceuticals – Implantable Materials – Implantable Devices – Surgical Aids – Diagnostic Tools – Genetic Testing – Imaging – Nanoparticles Probe – Case Analysis – 1) Resiprocytes – Mechanical Artificial Red Cells – 2) Using DNA as a construction medium	1
2	**Nanosensors** Chemical and Molecular Sensors – Displacement and Motion Sensors – Force Nanosensors – Pressure Sensing – Thermal Nanosensors – Electric and Magnetic Sensing – Cellular Bioscanning – Non-invasive Neuroelectric Monitoring – Macrosensing – Acoustic Macrosensing – Electric and Magnetic Macrosensing – Neural Macrosensing	2
3	**Basics of Drug Delivery System** Needs and Requirements – Nanoparticle Flow: Implications for Drug Delivery – Polymeric Nanoparticles as Drug Carriers and Controlled Release Implant Devices – Genetic Vaccines: A Role for Liposomes – Polymer Micelles as Drug Carriers – Recent Advances in Microemulsions as Drug Delivery Vehicles – Lipoproteins as Pharmaceutical Carriers – Solid Lipid Nanoparticles as Drug Carriers	3
4	**Nanocapsules** Nanocapsules – A New Drug Delivery System Nanocapsules preparation, Characterization and Therapeutic Applications – Dendrimers as Nanoparticulate Drug Carriers – Cells and Cell Ghost as Drug Carriers – Cochleates as Nanoparticular Drug Carriers – Aerosols as Drug Carriers – Magnetic Nanoparticles as Drug Carriers – Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders – Delivery of Nanoparticles to the Cardiovascular System – Nanocarriers for the Vascular Delivery of Drugs to the Lungs – Nanoparticulate Carriers for Drug Delivery to the Brain – Nanoparticles for Targeting Lymphatics – Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract – Nanoparticular Carriers for Ocular Drug Delivery – Nanoparticles and Microparticles as Vaccines Adjuvants – Pharmaceutical NanoCarriers in Treatment and Imaging of Infection.	4

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (CIA) a. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar b. Assignments B. Semester End examination

REFERENCES

1. Nano Medicines Edited by Dr. Parag Diwan and Ashish Bharadwaj, Pentagon Press(2006) ISBN 81-8274-139-4

2. Nanoparticulates as Drug Carriers Edited by Vladimir P.Torchilin, Imperial College Press, North Eastern University, USA (2006) ISBN 1-86094-630-5

3. Nanomedicine and Drug Delivery *Edited By Mathew Sebastian, Neethu Ninan, A. K. Haghi*I, SBN 9781774632352, Published by Apple Academic Press 2021

4. Nanomedicine in Drug Delivery *Edited By Arun Kumar, Heidi M. Mansour, Adam Friedman, Eric R. Blough,* ISBN 9781138072619, Published by CRC Press 2017

SEMESTER 4

Programme	Joint MSc					
Course Name	**Dissertation**					
Course Credit	**12**					
Type of Course	**CORE**					
Course Code	MGKUMPNSC49					
Course Summary & Justification	The candidate shall do a research project in any of the research institute. This follows discussion with the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner.					
Semester	**4**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Library work, lab work, Team work, independent learning	-	-	-	-	-
Pre-requisite	Should complete semester I, II and III.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course the students are expected to		
	To clearly present and discuss the research objectives, methodology, analysis, results and conclusions effectively.	A	2, 3, 4, 5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Gain deeper knowledge of methods in the topic of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6
7	Create, analyse and critically evaluate different problems and their solutions.	C	7
8	Gain a consciousness of the ethical aspects of research.	E	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, , Library work, laboratory work, Team work, independent learning and Group discussion, Presentation of research work.
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners.

Programme	Joint MSc					
Course Name	**Viva-Voce**					
Course Credit	**4**					
Type of Course	**CORE**					
Course Code	MGKUMPNSC50					
Course Summary & Justification	The comprehensive viva-voce shall be conducted by the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner. Thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of chemical sciences are evaluated					
Semester	**4**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Classroom studies, lab work, library Library work, independent learning etc.	-	-	-	-	-
Pre-requisite	Basic as well as in-depth knowledge in the courses he/she studied					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course the students are expected to		
1	Achieve fundamental and in-depth knowledge	A	3
2	Acquire more in-depth knowledge of the major subject of study	Ap	1,2,3,4,5,6,7
3	Deeper knowledge of methods in the major subject of study.	A	1, 4
4	Able to contribute to research and development work.	U	3
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, , Library work , laboratory work, Team work, independent learning and Group discussion, Presentation of research work
Assessment Types	**Mode of Assessment** Thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of chemical sciences are evaluated. The candidate will be asked questions based on the whole syllabus he/she studied in the entire programme. How he/she answered or responded the questions asked will be considered for evaluation.

ADD-ON COURSES

In addition to Core, elective and practical courses, School of Nanoscience and Nanotechnology, Mahatma Gandhi University will offer add-on courses such as;

- Nano catalysis
- Social, ethical and legal issues of Nanoscience and Nanotechnology
- Nano sensors
- Advanced nanobiology
- Waste management, and Water purification through Nanoscience and Nanotechnology.

The course structure and syllabus will be announced before commencement of each semesters. The lectures will be delivered by reputed Professors/ Scientists from other Universities/ Institutions in India or Abroad.

MODEL QUESTION PAPER

QP Code

Reg.No:
Name:

JOINT M. Sc. PROGRAMME

MAHATMA GANDHI UNIVERSITY & KANNUR UNIVERSITY

SEMESTER

END SEMESTER EXAMINATION (YEAR/ MONTH)

COURSE CODE: COURSE NAME

Time: 3 Hours **Max. Marks: 60**

Part A. Answer any 10 Questions (Each question carries 2 marks)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……
9. ……
10. ……
11. ……
12. ……
13. ……
14. ……

Part B. Answer any 4 Questions (Each question carries 5 marks)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……

Part C. Answer any 2 Question (Each question carries 10 marks)

1. ……
2. ……
3. ……
4. ……