

Course of Studies
for
Two-Year Master of Science (M.Sc.)
in
Chemistry
with
Specialization
in
Industrial Chemistry/Organic Chemistry
(Session 2019–2020 Onward)



Department of Chemistry
Veer Surendra Sai University of Technology (VSSUT)
Siddhi Vihar, P.O.: Engineering College
Burla, Sambalpur–768018, Odisha, India
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**Vision:**

- To prepare students to meet the ever-increasing demand of industries, research institutes, and teaching positions with analytical and practical skills.
- To equip the students with conceptual and experimental tools required to understand the molecular world.
- To provide a basic understanding of chemistry and the scientific methods that will enable the students to evaluate critically and informative decisions on issues relating to science, technology, and society at large.

Mission:

Mission 01: To develop the department as a center of excellence in the frontier area of chemical sciences and also to develop the department as a nodal center of consultancy for solving the problems in the field of analytical chemistry, qualitative analysis, and pollution control.

Mission 02: To encourage active participation of faculty members and students with industries for solving their day-to-day problems in chemistry and quality control and also to collaborate with institutions of national and international repute.

Mission 03: To encourage community engagement by providing students with teaching-learning and community based research opportunities.

Programme Educational Objectives (PEOs):

PEO 01: To pursue Ph.D. programme at national/global level research institute with CSIR-NET/GATE/TOEFL/GRE qualifications.

PEO 02: To achieve successful professional careers in chemical industries, government sectors, academia and national/international research institutes as innovative scientists.

PEO 03: To develop leadership skill, social awareness and responsibility, contemporary and global outlook that contribute to the development of the country.

PEO–Mission Mapping:

	PEO 01	PEO 02	PEO 03
Mission 01	2	3	3
Mission 02	3	3	3
Mission 03	1	2	3

Programme Outcomes (POs):

PO 01: Develop an understanding of major concepts, theoretical principles and experimental findings in chemistry and their application in day-to-day life.



PO 02: Ability to conduct experiments, analyze data, and interpret results, while observing responsible and ethical scientific conduct, and to work effectively in diverse teams in both classroom and laboratory.

PO 03: Apply/implement interface between the history of chemistry and natural science and, on the other hand, issues pertaining to the areas of modern technology, health, and environment.

PO 04: Exhibit mastery in the solution of research problems in Chemical Process Research and Development, and deductive problems in associated chemistry and chemical engineering.

PO 05: Knowledge of use modern techniques, equipment and chemistry software, proper procedures and regulations for safe handling and use of chemicals and can follow the proper procedures and regulations for safe handling when using chemicals.

PO 06: Apply various aspects of chemistry in industrial quality control, environmental analysis, natural products isolations, pharmaceuticals, dyes, textiles, polymers, petroleum products, forensic etc. and also to develop interdisciplinary approach of the subject.

Programme Specific Outcomes (PSOs):

PSO 01: To get in-depth knowledge on advanced concepts in Inorganic chemistry, Organic chemistry, Physical chemistry, Analytical chemistry, with a broad idea about some specialised topics related to Nano science and technology, Green chemistry, Environmental chemistry and Industrial chemistry.

PSO 02: To synthesize, purify and characterize compounds using established protocols, with the help of standard and modern instrumentation techniques and to find their applications in various fields, and learn to explore online search tools for literature survey of the topic of research, manuscript preparation and online submission for publication.

Course Outcomes:

Upon successful completion of the Course, the students will demonstrate the ability to:

CO1:

CO2:

CO3:

CO4:

CO5:

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1						



CO2

CO3

CO4

CO5

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course						



**Course Structure of Two-Year Master of Science (M.Sc.) in Chemistry with
Specialization in Industrial Chemistry/Organic Chemistry
(Session 2019–2020 Onward)**

01st SEMESTER

Code	Name of the Subject		L-T-P	Credits
MCH01001	Core 01	Structure and Reactivity	3-1-0	4
MCH01002	Core 02	Group Theory and Quantum Chemistry	3-1-0	4
MCH01003	Core 03	Thermodynamics and Chemical Dynamics	3-1-0	4
MCH01004	Core 04	Coordination Chemistry	3-1-0	4
MCH01005	Lab 01	Inorganic General Lab	0-0-3	2
MCH01006	Lab 02	Organic General Lab	0-0-3	2
	Audit 01		0-2-0	0
			Total Credit	20

02nd SEMESTER

Code	Name of the Subject		L-T-P	Credits
MCH02001	Core 05	Stereochemistry	3-1-0	4
MCH02002	Core 06	Organic Reaction Mechanism	3-1-0	4
MCH02003	Core 07	Organometallics	3-1-0	4
MCH02004	Core 08	Molecular Spectroscopy	3-1-0	4
MCH02005	Lab 03	Physical General Lab	0-0-3	2
MCH02006	Lab 04	Environmental and Analytical Lab	0-0-3	2
	Audit 02		0-2-0	0
			Total Credit	20

03rd SEMESTER

Code	Name of the Subject		L-T-P	Credits
MCH03001	Core 09	Photochemistry and Pericyclic Reactions	3-0-0	3
MCH03002	Core 10	Applications of Spectroscopic Techniques	3-0-0	3
	Elective I	Basket-I/Basket-II	3-1-0	4



Elective II	Basket-I/Basket-II	3-1-0	4
Open Elective		3-1-0	4
MCHOC301/ MCHIC301	Lab 05 Organic Synthesis Lab/Industrial Lab	0-0-3	2
Total Credit			20

04th SEMESTER

Code	Name of the Subject	L-T-P	Credits
Elective Paper III	Basket-I/Basket-II	3-1-0	4
Elective Paper IV	Basket-I/Basket-II	3-1-0	4
MCH04001	Project Dissertation	0-0-4	6
MCH04002	Industrial Training/Internship	0-0-3	0
MCH04003	Comprehensive Viva-Voce	0-0-0	2
Total Credit			16

Grand Total Credit = 20 + 20 + 20 + 16 = 76

List of Electives:

Basket-I (Organic Special):

1. Disconnection Approach in Organic Synthesis = MCHOC302
2. Supramolecular and Macromolecules = MCHOC303
3. Chemical Kinetics and Physical Photochemistry = MCHOC304
4. Environmental Chemistry and Management = MCHOC305
5. Reactions and Reagents in Organic Synthesis = MCHOC401
6. Bioorganic Chemistry = MCHOC402
7. Ring Synthesis = MCHOC403

Basket-II (Industrial Special):

1. Analytical Chemistry = MCHIC302
2. Industrial Process = MCHIC303
3. Chemical Kinetics and Physical Photochemistry = MCHIC304
4. Environmental Chemistry and Management = MCHIC305
5. Chemistry of Materials = MCHIC401
6. Materials and Energy Balance = MCHIC402
7. Colloids and Surface Chemistry = MCHIC403
8. Computational Chemistry = MCHIC404



Open Electives:

- | | |
|--------------------------------------------|------------|
| 1. Applied Nanoscience and Nanotechnology | = MCHOE901 |
| 2. Environmental Assessment and Management | = MCHOE902 |
| 3. Materials Science | = MCHOE903 |
| 4. Fuel and Energy | = MCHOE904 |
| 5. Science of Composite Materials | = MCHOE905 |

Audit:

1. English for Research Paper Writing
2. Disaster Management
3. Value Education
4. Constitution of India
5. Pedagogy Studies
6. Personality Development through Life Enlightenment Skills



**Syllabus of Two-Year Master of Science (M.Sc.) in Chemistry with
Specialization in Industrial Chemistry/Organic Chemistry
(Session 2019–2020 Onward)**

01st SEMESTER

Core 01 Code: MCH01001 Subject: Structure and Reactivity Credits: 4[3-1-0]

Module-I(07 Hours)

Nature of Bonding in Organic Molecules: Delocalized Chemical Bonding, Conjugation, Cross Conjugation, Resonance, Hyperconjugation, Bonding in Fullerenes, Tautomerism. Aromaticity in Benzenoid and Non-benzenoid Compounds, Alternant and Non-alternant Hydrocarbons, Huckel's Rule, Energy Levels of π -molecular Orbitals of Simple Systems, Annulenes, Anti-aromaticity, Homo-aromaticity.

Module-II(05 Hours)

Bonds Weaker than Covalent (Addition compounds): Crown Ether Complexes and Cryptands, Inclusion Compounds, Cyclodextrins, Catenanes and Rotaxanes.

Module-III(10 Hours)

Reaction Mechanism, Structure, and Reactivity: Types of Mechanisms, Types of Reactions, Thermodynamic and Kinetic Requirements, Kinetic and Thermodynamic Control, Hammond's Postulate, Curtin-Hammett Principle. Potential Energy Diagrams, Transition States and Intermediates, Methods of Determining Mechanisms, Hard and Soft Acids and Bases. The Hammett Equation and Linear Free Energy Relationship, Substituent and Reaction Constants. Taft Equation.

Module-IV(05 Hours)

Reaction Intermediates: Non-classical Carbocations, Generation and Structure of Free Radicals, Carbenes, Nitrenes, Arynes. General Discussion on Isotope Effect, Stereoselective, Regioselective, Stereospecific and Regiospecific Reactions.

Module-V(13 Hours)

Aliphatic Nucleophilic Substitution Reactions: S_N^2 , S_N^1 , Mixed S_N^1 and S_N^2 , and SET Mechanisms. The Neighboring Group Mechanism, Neighboring Group Participations by Sigma and Pi Bonds. Classical and Non-classical Carbocations, Phenonium Ions, Norbornyl System, Nucleophilic Substitution at Allylic, Aliphatic Trigonal and Vinylic Carbon. Reactivity Effects of Substrate Structure, Attacking Nucleophile, Leaving Group and Reaction Medium, Phase Transfer Catalysis, Ambident Nucleophile, Regioselectivity.

Books Recommended:



1. J. March, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 4th Edition, John Wiley and Sons, 1992.
2. N.S. Isaacs, Physical Organic Chemistry, 2nd Edition, Prentice Hall, 1996.
3. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition, Benjamin-Cummings, 1997.
4. R.T. Morrison and R.N. Boyd, Organic Chemistry, 6th Edition, Pearson Education, 2009.
5. M.G. Moloney, Structure and Reactivity in Organic Chemistry, 1st Edition, Blackwell, 2008.
6. H. Maskill, Structure and Reactivity in Organic Chemistry, 1st Edition, Oxford University Press, 1999.
7. S.N. Ege, Organic Chemistry: Structure and Reactivity, 5th Edition, Houghton Mifflin Harcourt, 2003.

Course Outcomes:

CO1: To analyze concepts of bonding, structure, properties and applications of complex organic compounds.

CO2: To create awareness on non-covalent bonding, host-guest complexation, molecular machines.

CO3: To analyze and implement the concept of kinetics and thermodynamics in organic reactions.

CO4: To evaluate the generation, reaction and identification of intermediates used during organic reactions and their applications in organic reaction mechanisms.

CO5: To incorporate and evaluate nucleophilic substitutions on aliphatic substrates.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	0	2	2	2	1
CO2	3	2	3	2	0	0
CO3	1	3	3	3	3	3
CO4	3	0	0	3	3	2
CO5	3	1	1	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
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Course 3 2 2 2 1 1

Core 02Code: MCH01002Subject: Group Theory and Quantum Mechanics Credits: 4 [3-1-0]

Module-I(10 Hours)

Group Theory–I: Symmetry Elements and Symmetry Operations, Matrix Representation of Symmetry Operation, Classes of Operations, Point Groups (C_1 , C_s , C_i , C_n , C_{nv} , C_{nh} , S_{2n} , D_n , D_{nd} , D_{nh} , T_d , O_h , I_h , $D_{\infty v}$, and $C_{\infty v}$), Properties of Point Groups, Irreducible and Reducible Representation, Bases of Representation, Character of a Representation, Reduction Formula

Module-II(10 Hours)

Group Theory–II: The Great Orthogonality Theorem (Without Proof) and its explanation, Construction of Character Tables for C_{2v} , C_{3v} , T (Cubic), C_4 (Cyclic) and D Groups, Projection Operator and Direct Product, Normal Mode of Analysis

Module-III(10 Hours)

Wave Mechanics of Some Systems: Postulates of Quantum Mechanics, Quantum Mechanical Operators, Application of Schrodinger Wave Equation to Particle in a Box, Harmonic Oscillator, Rigid Rotator, and Hydrogen Atom, Transformation of Co-ordinates, Separations of Variables, and R Equations, Spherical Harmonics, Shapes of s, p and d Orbital, Probability density in 1s Orbital, Physical Interpretation of Hydrogen Orbitals, Radial Distribution Function and Curves.

Module-IV(10 Hours)

Angular Momentum: Definition, Generalized Angular Momentum, Eigen Functions and Eigen Values of Angular Momentum, Operator using Ladder Operators, Addition of Angular Moments, Mutual Interaction of Electron Orbitals and Resultant Vectors, Russel-Saunders's Coupling, j-j Coupling, Ground State Term Symbols and Hund's Rule, Micro States and Derivation of Russel-Saunders's Term for P^2 , d^2 and pd Configuration.

Module-V(10 Hours)

Approximation Methods: Variation Theorem and its Application to Hydrogen atom in Derivation of its Ground State Energy, Perturbation Theory (First Order and Non-degenerate), Secular Equations, Linear Combination of Atomic Orbitals (LCAO) Approximation (Molecular Orbital Theory) and Its Application to Hydrogen Molecule Ion, Hückel Theory of Conjugated Systems, Bond Order, and Charge Density Calculations, Applications to Ethylene, Butadiene, Cyclopropenyl Radical, Cyclobutadiene, etc., Spin and Anti-symmetric Nature of Wave Function (Pauli's Exclusion Principle)

Books Recommended:



1. F.A. Cotton, Chemical Applications of Group Theory, 3rd Edition, John Wiley and Sons, 1990.
2. A. Vincent, Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Application, 2nd Edition, John Wiley and Sons, 2001.
3. A.M. Lesk, Introduction to Symmetry and Group Theory for Chemists, 1st Edition, Kluwer Academic Publishers, 2004.
4. K.V. Reddy, Symmetry and Spectroscopy of Molecules, New Age Science, 2nd Edition, 2009.
5. P.K. Bhattacharya, Group Theory and Its Chemical Applications, 2nd Edition, Himalaya Publishing House, 2014.
6. K.C. Molloy, Group Theory for Chemists: Fundamental Theory and Applications, 2nd Edition, Woodhead Publishing, 2013.
7. R.K. Prasad, Quantum Chemistry, 4th Edition, New Age Science, 2009.
8. I.N. Levine, Quantum Chemistry, 7th Edition, Pearson Education, 2016.
9. D.A. McQuarrie, Quantum Chemistry, 2nd Revised Edition, University Science Books, 2007.

Course Outcomes:

CO1: The course delivers the fundamental knowledge of Symmetry operations and symmetry elements and its matrix representations.

CO2: Fundamental knowledge regarding application of group theory in chemistry.

CO3: Quantum mechanics describe the nature at the smallest scales of energy levels of atoms and subatomic particles.

CO4: Quantum mechanics give the in depth idea about the spectroscopy.

CO5: The major outcome of quantum chemistry includes increasing accuracy of the results for small molecular systems by using different approximation methods. Quantum mechanics also solve the orbital theories of chemistry.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	2	1	1
CO2	3	3	3	3	1	1
CO3	2	3	1	3	2	1
CO4	3	3	1	3	2	1



CO5 3 2 2 3 2 1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Core 2	3	3	2	3	2	1

Core 03 Code: MCH01003 Subject: Thermodynamics and Chemical Dynamics Credits: 4 [3-1-0]

Module-I(08 Hours)

Classical Thermodynamics: Concepts of Laws of Thermodynamics, Chemical Potential and Entropy, Third Law of Thermodynamics and Determination of Entropy, Entropy and Probability, Boltzmann-Planck Equation, Partial Molar Properties (Partial Free Energy, Molar Volume and Molar Heat Content), Their Significance and Determination. Concept of Fugacity and its Determination.

Module-II(08 Hours)

Statistical Thermodynamics: Thermodynamic Probability and Most Probable Distribution. Ensemble Averaging, Postulates of Ensemble Averaging, Canonical, Grand Canonical and Micro-Canonical Ensembles, Stirling Formula, Partition Functions (Translational, Rotational, vibrational and Electronic Partition Functions), Applications of Partition Functions.

Module-III(08 Hours)

Fermi-Dirac Statistics, Bose-Einstein Statistics, Most Probable Distribution, Sackure-Tetrode Equation, Relationship between Partition Function and Enthalpy, Relationship between Partition Function and Equilibrium Constant, Energy Fluctuation in Canonical Ensemble

Module-IV(08 Hours)

Electrochemistry: Derivation of Onsager Limiting Law and Its Verification and Modification, Activities, Activity Coefficients, Debye-Hückel Treatment, Debye-Huckel-Brønsted Equation, Salt Effect, Determination of Activity Coefficients from Solubility Method, Determination of Thermodynamic Dissociation Constant of Weak Electrolytes by EMF Method, Amino Acid, Hydrogen Ion Concentration, Ampholytes, Isoelectric Points, Stern model.

Module-V(08 Hours)

Chemical Kinetics: Theories of Reaction Rates, Collision Theory, Transition State Theory of Uni- and Bimolecular Reactions, Lindemann Mechanism. Arrhenius and Activated



Complex, Reaction between Ions, Steady-State Kinetics, Kinetic and Thermodynamic Concept of Reactions, Pyrolysis of CH_3CHO

Fast Reactions: Study of Fast Reactions by Relaxation, Stopped Flow, Flash Photolysis

Books Recommended:

1. K.L. Kapoor, A Textbook of Physical Chemistry, Volume I–IV, 3rd Edition, Macmillan, 2012.
2. D.N. Bajpai, Advanced Physical Chemistry, 2nd Edition, S. Chand and Sons, 2001.
3. P. Atkins and J. de Paula, Physical Chemistry, 9th Edition, W.H. Freeman, 2009.
4. S.K. Dogra and S. Dogra, Physical Chemistry through Problems, 2nd Edition, New Age International, 2015.
5. D.V.S. Jain and S.P. Jauhar, Physical Chemistry: Principles and Problems, 1st Edition, Tata McGraw-Hill, 1988.
6. R. P. Rastogi and R. R. Misra, An Introduction to Chemical Thermo-dynamics, 6th Edition, Vikas Publishing, 2009.
7. S. Glasstone, Thermodynamics for Chemists, 1st Edition, Affiliated East-West Press, 2008.
8. R. Haase, Thermodynamics of Irreversible Processes, 1st Edition, Addison-Wesley, 1968.
9. I. Prigogine, Introduction to Thermodynamics of Irreversible Processes, 3rd Edition, Interscience Publishers, 1968.
10. M.C. Gupta, Statistical Thermodynamics, 2nd Edition, New Age International, 2007.
11. S. Glasstone, An Introduction to Electrochemistry, Maurice Press, 2008.
12. A.A. Frost and R.G. Pearson, Kinetics and Mechanism, 2nd Edition, John Wiley and Sons, 1961.

Course Outcomes:

CO1: Express and analyze first law and to define heat, work, thermal efficiency and the difference between various forms of energy.

CO2: Organize, identify and describe energy exchange processes (in terms of various forms of energy, heat and work) in the aerospace systems.

CO3: Explanation of the level understanding, how various heat engines work (e.g. a refrigerator, an IC engine, a jet engine).

CO4: Express the steady-flow energy equation or the first Law of Thermodynamics to a system of thermodynamic components (heaters, coolers, pumps, turbines, pistons, etc.) to estimate required balance of heat, work and energy flow.



CO5: Explain and demonstrate the level of understandable, the concepts of path dependence/independence and reversibility/irreversibility of various thermodynamic processes, to represent these in terms of changes in thermodynamic state, and to cite examples of how these would impact the performance of aerospace power and propulsion systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	2	2	3	2
CO3	3	3	2	2	3	2
CO4	3	3	2	2	3	2
CO5	3	3	2	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	3	2

Core 04 Code: MCH01004 Subject: Coordination Chemistry Credits: 4 [3-1-0]

Module-I(08 Hours)

Theories of Metal-Ligand Bonding

Crystal Field Theory: Important Aspects of Crystal Field Theory, d-Orbitals Splitting in Octahedral, Tetrahedral and Square Planar Complexes, $10Dq$ Value and Its Calculation, Crystal Field Stabilization Energy (CFSE) in Weak Field and Strong Field Cases, Factors Affecting Magnitude of $10Dq$, Spectrochemical Series, Jahn-Teller Effect, Applications of Crystal Field Theory (Color and Magnetic Properties of Complexes), Limitations of Crystal Field Theory.

Module-II(08 Hours)

Molecular Orbital Theory (MOT): Nephelauxetic effect, MO Energy Level Diagrams for Octahedral, Tetrahedral and Square Planar Complexes, Measurement of π -Bonding Effects.

Study of Complexes in Solution: Introduction to Stability Constants, Factors Affecting Stability Constants, Kinetic and Thermodynamic Stability, , Inert and Labile Complexes ,Irving-William Series, Methods of Determining Stability Constants (Spectrophotometric and pH-metric Methods).



Module-III(08 Hours)

Electronic Spectra of Metal Complexes: Spectra of Transition Metal Ions, Term Symbols of d^n Ions, Free Ions in Weak Fields and Strong Crystal Fields, Weak Field Configurations, Orgel Diagrams for d^n Ions, *Tanabe-Sugano* Diagrams, Charge Transfer Transitions, Selection Rules and Transition Probabilities Based on Symmetry Considerations.

Module-IV(08 Hours)

Magnetic Properties of Complexes: Types of Magnetism (Dia-, Para-, Ferro- and Anti-ferromagnetism), Temperature Independent Paramagnetism, Magnetic Susceptibility and Its Determination by Gouy and Faraday Methods, Calculation of Magnetic Moment from Magnetic Susceptibility, Spin-Orbit Couplings and Its Effect on Magnetic Moments, Orbital Contribution to Magnetic Moment.

Module-V(08 Hours)

Reaction Mechanism of Transition Metal Complexes: Energy Profile of a Reaction, Reactivity of Metal Complexes, Kinetics of Octahedral Substitution. Acid Hydrolysis, Factors Affecting Acid Hydrolysis, Base Hydrolysis, Conjugate Base Mechanism, Direct and Indirect Evidences in Favor of Conjugate Mechanism, Anation Reactions, Reactions without Metal Ligand Bond Cleavage. Substitution Reactions in Square Planar Complexes. The Trans Effect, Mechanism of One Electron Transfer Reactions, Outer Sphere Type Reactions, Inner Sphere Type Reactions.

Books Recommended:

1. W.U. Malik, G.D. Tuli, and R.D. Madan, Selected Topics in Inorganic Chemistry, 17th Edition, S. Chand and Sons, 2010.
2. J.E. Huheey, E.A. Keiter and R.L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, Prentice Hall, 1997.
3. F.A. Cotton and G. Wilkinson, C.A. Murillo, and M. Bochmann, Advanced Inorganic Chemistry, 6th Edition, John Wiley and Sons, 2009.
4. F. Basolo and R.G. Pearson, Mechanisms of Inorganic Reactions, 2nd Edition, Byte/McGraw-Hill, 1965.
5. F. Basolo and R. Johnson, Coordination Chemistry, W.A. Benzamin, 1964.
6. D. Banerjea, Coordination Chemistry, 3rd Edition, Asian Books, 2009.
7. D. Nichols, Complexes and First Row Transition Elements, 1st Edition, Macmillan, 1974.
8. O. Kahn, Molecular Magnetism, 1st Edition, Wiley-VCH, 1993.
9. J.R. Gispert, Coordination Chemistry, 1st Edition, John Wiley and Sons, 2008.



10. G.A. Lawrance, Introduction to Coordination Chemistry, 1st Edition, John Wiley and Sons, 2010. V. Balzani and V. Carasitti, Photochemistry of Coordination Compounds, 1st Edition, Academic Press, 1970.
11. R.B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 2nd Edition, Oxford University Press, 1991.
12. G. Wulfsberg, Inorganic Chemistry, University Science Books, 2000.
13. R.K. Sharma, Text Book of Coordination Chemistry, 1st Edition, Discovery Publishing, 2007.
14. R. Gopalan and V. Ramalingam, Concise Coordination Chemistry, 1st Edition, Vikas Publishing, 2009.

Course Outcomes:

CO1: To be able to use Crystal Field Theory to understand splitting and the magnetic properties (and in simple terms the color) of coordination compounds.

CO2: To be able to use Molecular orbital theory to understand the bonding in coordination compounds and to describe the difference between Thermodynamic stability and Kinetic stability and the stability of metal complexes by the use of formation constants and to calculate thermodynamic parameters from them.

CO3: To demonstrate the electronic spectra of octahedral and tetrahedral complexes by using Orgel diagrams.

CO4: Interpretation of magnetic properties of complex compounds and to be able to determine the magnetic moment of complex compounds.

CO5: To be familiar with classification of inorganic reaction mechanisms and the mechanism of substitution at square-planar complexes, substitution at octahedral complexes and the mechanism of electron transfer reactions.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	1
CO2	3	2	3	2	2	1
CO3	3	2	3	3	2	1
CO4	3	2	3	3	2	1
CO5	3	2	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

Department of Chemistry

Veer Surendra Sai University of Technology (VSSUT)

Siddhi Vihar, P.O.: Engineering College, Burla, Sambalpur-768018, Odisha, INDIA



	PO1	PO2	PO3	PO4	PO5	PO6
Core 4	3	2	3	3	2	1

Lab 01 Code: MCH01005 Subject: Inorganic General Lab Credits: 2 [0-0-3]

Analysis of an Inorganic Mixture containing not more than six radicals. The mixture will include rare earth like Tungstate, Vanadate, Molybdate and Cerium (IV). Insoluble matters and other interfering radicals will also be included. Organic radicals are excluded.

CO1: Apply the principles of Common ion effect and solubility effect in qualitative analysis.

CO2: To develop the concepts behind the separation cations and anions.

CO3: To analyze the principles behind the identifications of different radicals.

CO4: Organize the radicals into different groups.

CO5: Demonstrate and use the different reagents for identifications of cations and anions

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	2	1
CO2	3	2	1	3	2	1
CO3	3	2	1	3	2	1
CO4	3	2	1	3	2	1
CO5	3	2	1	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	1	3	2	1

Lab 02 Code: MCH01006 Subject: Organic General Lab Credits: 2 [0-0-3]

Qualitative Analysis:

Identification of Unknown Organic Compounds, Separation, Purification and Identification of Compounds of Binary Mixture (both are Solids, One Liquid and One Solid) using TLC and Column Chromatography, Chemical Tests.

Books Recommended:

1. D. Pasto, C.R. Johnson, and M. Miller, Experiments and Techniques in Organic Chemistry, Instructor's Edition, Prantice Hall, 1992.
2. H. Middleton, Systematic Qualitative Organic Analysis, 1st Edition, Edward Arnold, 1939.



3. H.T. Clarke, Hand Book of Organic Analysis: Qualitative and Quantitative, 5th Revised Edition, Hodder Arnold, 1975.
4. A.I. Vogel, A.R. Tatchell, B.S. Furnis, A.J. Hannaford, P.W.G. Smith, Vogel's Text Book of Practical Organic Chemistry, 5th Edition, Prentice Hall, 1989.
5. K.L. Williamson, Macroscale and Microscale Organic Experiments, 2nd Edition, D.C. Heath, 1994.
6. A.I. Vogel, Textbook of Practical Organic Chemistry Including Qualitative Organic Analysis, 3rd Revised Edition, Prentice Hall Press, 1956.

Course Outcomes:

CO1: Apply and evaluate the unknown organic compounds.

CO2: Demonstrate the separation, purification and identification of compounds of binary mixture.

CO3: Define and demonstrate the unknown organic compounds.

CO4: Apply the fundamental idea to demonstrate the TLC.

CO5: Demonstrate and use the different reagents for identifications of various organic compounds.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	2	3	2	2
CO3	3	2	2	3	2	2
CO4	3	2	2	3	2	2
CO5	3	2	2	3	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	3	2	2

02nd SEMESTER

Core 05 **Code: MCH02001** **Subject: Stereochemistry** **Credits 4 [3-1-0]**

Module-I (08 Hours)

Chirality, Fischer Projection and R and S Notations, Threo and Erythro Nomenclature, E and Z Nomenclature, Optical Isomerism in Biphenyls and Allenes.

Module-II (08 Hours)



Concept of Prostereoisomerism and Asymmetric Synthesis, Enzymatic and Catalytic Nexus, stereoselective and stereospecific synthesis.

Module-III (08 Hours)

Conformational analysis: Conformation of Acyclic Molecules (Alkanes, Haloalkanes), Conformation of Cyclic Systems Having One and Two sp^2 Carbon Atoms.

Module-IV (08 Hours)

Dynamic Stereochemistry: Conformation and Reactivity, Selection of Substrates, Quantitative Correlation between Conformation and Reactivity, (Weinstein-Eliel Equations and Curtin-Hammett Principles),

Module-V(08 Hours)

Conformational Effects on Stability and Reactivity in Acyclic Compounds (Ionic Elimination, Intramolecular Rearrangements, NGP) and in Cyclic Systems (Nucleophilic Substitution Reaction at Ring Carbon, Formation and Cleavage of Epoxide Rings, Addition Reactions to Double Bonds, Elimination Reactions).

Books Recommended:

1. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 4th Edition, New Academic Science, 2012.
2. P.S. Kalsi, Stereochemistry: Conformation and Mechanism, 7th Edition, New Age International, 2009.
3. E.L. Eliel and S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley and Sons, 1994.
4. E. Eliel, Stereochemistry of Carbon Compounds, 1st Edition, Tata McGraw-Hill Education, 2008
5. D.G. Morris, Stereochemistry, Royal Society of Chemistry, 1st Edition, 2002.
6. M. North, Principles and Applications of Stereochemistry, 1st Edition, Stanley Thornes, 1998.
7. K. Mislow, Introduction to Stereochemistry, 3rd Edition, Dover Publications, 2002.

Course Objective:

CO1: To demonstrate the fundamental concepts that are required to analyze chiral compounds using Chirality, Fischer projection and R and S notations.

CO2: To incorporate the concept of prostereoisomerism and asymmetric synthesis (including enzymatic and catalytic nexus).

CO3: To create new chiral molecules using Asymmetric synthesis.



CO4: To analyze the reaction mechanism based on Correlation between Conformation and Reactivity.

CO5: To demonstrate the Applications of Conformation of a few acyclic molecules (alkanes, haloalkanes), Conformation of cyclic systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	1
CO2	3	2	3	2	2	1
CO3	3	2	3	3	2	1
CO4	3	2	3	3	2	1
CO5	3	2	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	3	2	1

Core 06 Code: MCH02002 Subject: Organic Reaction Mechanism Credits: 3 [4-0-0]

Module-I(10 Hours)

Aliphatic Electrophilic Substitution Mechanism: S_E^1 , S_E^2 and S_E^i Mechanisms, Effect of Substrate, Leaving Group and Solvent, Reactions (Hydrogen Exchange, Migration of Double Bonds, Keto-Enol Tautomerism, Halogenation, Aliphatic Diazonium Coupling, Stork-Enamine Reaction).

Aromatic Electrophilic Substitution Mechanism: Structure Reactivity, Relationship in Mono-substituted Benzene, Orientation in Benzene Ring with More than One Substituent, Vilsmeier-Haack Reaction, Pechmann Reaction.

Module-II(10 Hours)

Aromatic Nucleophilic Substitution Mechanism: Introduction, Mechanisms of Aromatic Nucleophilic Substitutions (S_{NAr} , S_N^1 , Aryne), Effect of Substrates, Leaving Groups, and Nucleophile, Reactions: Nucleophilic Displacement in Areno-diazonium Salts by Different Nucleophiles, Chichibabin Reaction.



Addition to Carbon-Carbon Multiple Bonds: Electrophilic, Nucleophilic and Free Radical Addition, Orientation and Reactivity, Addition to Cyclopropanes, Reactions: Hydroboration, Michael Reaction, Sharpless Asymmetric Epoxidation.

Module-III(06 Hours)

Addition to Carbon-Heteroatom Multiple Bonds: Mechanism and Reactivity, Reactions: Mannich Reaction, LiAlH_4 Reduction of Carbonyl Compounds, Acids, Esters, Nitriles, Addition of Grignard Reagents, Reformatsky Reaction, Aldol Condensation, Knoevenagel Condensation, Perkin Reaction, Tollens Reaction, Wittig Reaction, Prins Reaction, Benzoin Condensation.

Module-IV(08 Hours)

Elimination Mechanism: E^1 , E^2 , E^1_{CB} Mechanisms, Orientation, Effect of Substrate, Base, Leaving Group and Medium, Orientation of Double Bond, Saytzeff and Hoffman Rules, Pyrolytic Elimination Reaction, Oxidative Elimination (Oxidation of Alcohol by Chromium, Moffatt Oxidation). Reactions: Cleavage of Quaternary Ammonium Hydroxides, Chugaev Reaction, Shapiro Reaction.

Module-V(06 Hours)

General Mechanistic Considerations: Nature of Migration, Migratory Aptitude, Memory Effects, Detailed Study of the Following Rearrangements: Wagner-Meerwein, Favorskii, Arndt-Eistert Synthesis, Neber, Hofmann, Baeyer-Villiger, Sommelet-Hauser Rearrangement.

Books Recommended:

1. J. March, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 4th Edition, John Wiley and Sons, 1992.
2. P.S. Kalsi, Organic Reactions and Their Mechanisms, 3rd Edition, New Age International, 2009.
3. R. K. Bansal, Organic Reaction Mechanisms, 3rd Edition, Tata McGraw Hill, 2006.
4. N.S. Isaacs, Physical Organic Chemistry, 2nd Edition, Prentice Hall, 1996.
5. R.B. Grossman, The Art of Writing Reasonable Organic Reaction Mechanisms, 2nd Edition, Springer, 2003.
6. R. Bruckner and M. Harmata, Organic Mechanisms: Reactions, Stereochemistry and Synthesis, Springer, 2010.
7. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press, 2002.
8. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Edition, Pearson Education, 2009.



9. A. Miller and P.H. Solomon, Writing Reaction Mechanisms in Organic Chemistry, 2nd Edition, Academic Press, 2000.

Course Outcomes:

CO1: Evaluation and application of electrophilic substitution on organic substrates.

CO2: Evaluation and application of nucleophilic substitution on aromatic substrates; Evaluation and application of electrophilic addition processes.

CO3: Evaluation and application of nucleophilic addition of organic substrates.

CO4: Evaluation and application of elimination reaction mechanisms.

CO5: Demonstration of applications of mechanisms on some organic synthetic reactions.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	0	1	3	2	1
CO2	3	0	1	2	1	0
CO3	3	0	1	3	3	1
CO4	3	0	1	2	0	2
CO5	3	0	1	2	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	0	1	2	1	1

Core 07 Code: MCH02003 Subject: Organometallics Credits: 4 [3-1-0]

Module-I(08 Hours)

Compounds of Transition Metal Carbon Multiple Bonds (Alkylidines, Alkylidyne, Low Valent Carbenes and Carbenes): Synthesis Nature of Bonding and Structural Characteristics, Nucleophilic and Electrophilic attack on Coordinating Ligands.

Module-II(08 Hours)

Transition Metal Pi Complexes with Unsaturated Organic Molecules (Alkenes, Alkynes and Allyl, Diene Complex): Preparation, Properties, Nature of Bonding and Structural Features

Module-III(08 Hours)

Transition Metal Pi Complexes with Unsaturated Organic Molecules (Dienyl, Arene and Trienyl Complexes): Preparation, Properties, Nature of Bonding and Structural Features.

Module-IV(08 Hours)



Reactions in Organometallic Chemistry: Coordinating Unsaturation, Oxidative Addition Reaction, Stereochemistry and Mechanism of Addition, Reductive elimination reaction, Insertion Reactions, Intra Molecular Hydrogen Transfer, Isomerization,

Module-V(08 Hours)

Homogeneous Catalysis using Organometallic Compounds: Hydrogenation of Alkenes, Hydroformylation, Olefin Metathesis, Olefin Polymerization, Zigler-Natta Polymerization.

Books Recommended:

1. J.P. Collman, L.S. Hegedus, J.R. Norton, and R.C. Finke, Principles and Applications of Organotransition Metal Chemistry, 2nd Edition, University Science Books, 1987.
2. R.H. Crabtree, The Organometallic Chemistry of the Transition Metals, 6th Edition, John Wiley and Sons, 2014.
3. A.J. Pearson, Metallo-Organic Chemistry, 1st Edition, John Wiley and Sons, 1985.
4. R.C. Mehrotra and A. Singh, Organometallic Chemistry, 2nd Edition, New Age International, 2014.
5. B.D. Gupta and A.J. Elias, Basic Organometallic Chemistry: Concepts, Syntheses, and Applications of Transition Metals, 1st Edition, CRC Press, 2010.
6. J.F. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, 1st Edition, University Science Books, 2010.
7. D. Astruc, Organometallic Chemistry and Catalysis, 1st Edition, Springer, 2007.
8. G.O. Spessard and G.L. Miessler, Organometallic Chemistry, 3rd Edition, Oxford University Press, 2015.

Course Outcomes:

CO1: To analyze the structure, bonding and reactivity of compounds of transition metal carbon multiple bonds.

CO2: To evaluate the structure, bonding and reactivity transition metal Pi Complexes with unsaturated aliphatic organic molecules.

CO3: To evaluate the structure, bonding and reactivity transition metal Pi Complexes with unsaturated aromatic organic molecules

CO4: To be able to identify the basic fundamental reactions in organometallic chemistry.

CO5: To be able to establish the structure-reactivity/activity relationship and the operating mechanisms in the catalytic processes.

Course Articulation Matrix

PO1	PO2	PO3	PO4	PO5	PO6
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CO1	3	2	2	2	1	1
CO2	3	2	2	2	1	1
CO3	3	2	2	2	1	1
CO4	3	2	2	2	1	1
CO5	3	2	2	2	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	2	1	1

Core 08 **Code: MCH02004** **Subject: Molecular Spectroscopy** **Credits: 4 [3-1-0]**

Module-I(08 Hours)

Atomic Spectroscopy: Electromagnetic Spectrum, General Discussion on Various Molecular Excitation Processes, Spectra of Hydrogen and Hydrogen Like Atoms, Alkali Metals Spectra, L-S Coupling, Term Symbols, Space Quantization, Zeeman Effect, Stark Effect, Paschen-Back Effect.

Module-II(08 Hours)

Vibrational and Rotational Spectroscopy: Molecular Spectra of Diatomic Gases, Classification of Molecules, Rotational Spectra, Vibrational Spectra, Vibrational-Rotational Spectra, P, Q and R Branches.

Module-III(08 Hours)

Raman Spectroscopy: Theory of Raman Spectra, Rotational Raman Spectra, Vibrational Raman Spectra, Rotational-Vibrational Raman Spectra, comparison with IR spectra.

Module-IV(08 Hours)

Photoelectron Spectroscopy: Basic Principles, Photoelectric effect, Ionization Process, Koopman's Theorem. Photoelectron Spectra of Simple Molecules, ESCA, Chemical Information from ESCA. Auger Electron Spectroscopy – Basic Idea.

Mossbauer Spectroscopy: Principles of Mossbauer Spectroscopy, Experimental Methods, Theoretical Aspects, Quadrupole Splitting, Magnetic Hyperfine Interaction.

Module-IV(08 Hours)

Laser Spectroscopy: Stimulated Absorption and Emission, Relations between the Einstein's Coefficients, Idea of Lasing Action, Methods to Create Population Inversion, Principle of Pumping Schemes, Requirements and Rate Equations for Lasers, Experimental Aspect of



Lasers, Characteristics of Laser Beams, Methods Of Q-Switching, Wavelength Range and Power Output of Lasers, Few Specific Laser Systems, Application of Lasers.

Books Recommended:

1. C.N. Banwell and E.M. McCash, Fundamentals for Molecular Spectroscopy, 5th Edition, Tata McGraw-Hill Education, 2013.
2. J.M. Hollas, Modern Spectroscopy, 4th Edition, John Wiley and Sons, 2004.
3. S.K. Dogra and H.S. Randhawa, Atomic and Molecular Spectroscopy, 1st Edition, Pearson India, 2015.
4. G. Aruldas, Molecular Structure and Spectroscopy, 2nd Edition, Prentice Hall India Learning, 2014.
5. H. Windawi and F.F.L. Ho, Applied Electron Spectroscopy for Chemical Analysis, John Wiley and Sons, 1982.
6. R.V. Parish. NMR, NQR, EPR and Mössbauer Spectroscopy in Inorganic Chemistry, Ellis Horwood, 1990.
7. R.S. Drago, Physical Methods for Chemists, 2nd Edition, Saunders College Publishing, 1992.
8. G.M. Barrow, Introduction to Molecular Spectroscopy, 1st Edition, McGraw-Hill, 1962.
9. R. Chang, Basic Principles of Spectroscopy, 1st Edition, McGraw-Hill, 1971.
10. H.H. Jaffe and M. Orchin, Theory and Applications of Ultraviolet Spectroscopy, 1st Edition, John Wiley and Sons, 1966.
11. P. K. Ghosh, Introduction to Photoelectron Spectroscopy, John Wiley and Sons, 1983.
12. A. Carrington and A.D. McLachlan, Introduction to Magnetic Resonance, 1st Edition, Harper and Row, 1967.

Course Outcomes:

CO1: How light interacts with matter and electromagnetic spectrum.

CO2: Microwave, Infrared, Rotational-Vibrational Spectra and their applications for chemical analysis.

CO3: Qualitative description about principle of Raman spectroscopy and its application in chemical analysis.

CO4: Electronic spectroscopy of different elements and simple molecules. Mossbauer spectroscopy and its application.

CO5: Laser spectroscopy and its application.

Course Articulation Matrix



	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	2	3	2	3
CO4	3	3	2	3	2	3
CO5	3	3	2	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	2	3

Lab 03 Code: MCH02005 Subject: Physical General Lab Credits: 2 [0-0-3]

Any Six from the Following

1. Determination of ionization constants of weak acids and verification of Oswald's Dilution law.
2. Verification of Onsager's limiting law.
3. Conductometric titration of a mixture of acids (HCl+CH₃COOH) with base (NaOH)
4. Determination of solubility product of BaSO₄.
5. Potentiometric titration of strong acid with strong base.
6. Determination of Iron in a water sample by colorimetry.
7. Verification of additivity rule spectrophotometrically.
8. Determination of temperature coefficient and energy of activation of hydrolysis of ethyl acetate.
9. To determine the rate constant of base hydrolysis of ester titrimetrically.
10. To study the complex formation between ammonia and Cu²⁺.
11. Study of inversion of cane sugar in acid medium by polarimetry.

Books Recommended:

1. R.C. Das and B. Behera, Experimental Physical Chemistry, McGraw-Hill, 1984.
2. J.M. Wilson, R.J. Newcombe, and A.R. Denaro, Experiments in Physical Chemistry, 2nd Edition Pergamon, 1968.

Course Outcomes:

CO1: Apply the principles of physical chemistry in the quantitative analysis.

CO2: Evaluate the end point of a titration by instrumental technique.



CO3: Demonstrate and use the different instruments including Conductivity meter, potentiometer, colorimeter, PH meter, UV-Visible spectrophotometer, polarimeter, etc. in analysis.

CO4:Analyze kinetics of different reactions.

CO5: Verify different laws such as Oswald's Dilution law, Onsager's limiting law and additivity rule taking suitable reaction system.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	1
CO2	3	2	1	1	2	1
CO3	3	2	2	2	1	1
CO4	3	2	1	2	2	1
CO5	3	2	2	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	2	2	1

Lab 04Code: MCH02006 Subject: Environmental and Analytical Lab Credits: 2 [0-0-3]

1. Determination of alkalinity of water sample.
2. Determination of dissolved oxygen and BOD in a sample of water.
3. Determination of iron content in a sample of water.
4. Determination of sulphate in Water sample.
5. Determination of Chemical Oxygen Demand (COD).
6. Determination of available chlorine in bleaching powder.
7. Determination of Cr^{+6} Content in a Sample of Water (spectrophotometrically).
8. Determination Organic Carbon in Soil Sample.
9. Determination of Phosphate in Garden Soil.
10. Determination of Nitrate in Water Sample.
11. Estimation of Gaseous Pollutants (SO_x and NO_x) in Ambient Air.
12. Estimation of suspended and respirable particulate matter (SPM and RPM) in ambient air.
13. Determination of composition of a complex by Job's method



14. Determination of stability constant of a complex.

15. Quantitative analysis of Cement.

16. Quantitative analysis of Dolomite.

Books Recommended:

1. A. Nigam and R. Gupta, Environmental Analysis Laboratory Handbook, 1st Edition, Wiley-Scrivener, 2020.
2. S. Mitra, P. Patnaik, and B.B. Kezbekus, Environmental Chemical Analysis, 2nd Edition, CRC Press, 2018.
3. P. Konieczka and J. Namiesnik, Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach, 1st Edition, CRC Press, 2009.
4. E. Prichard, Quality in the Analytical Chemistry Laboratory, 1st Edition, Wiley–Blackwell, 1995.

Course Outcomes:

CO1:Analyze the alkalinity and BOD value of the water sample.

CO2:Analyze the concentration of iron, nitrate and sulphate present in the water sample.

CO3:Analyze the COD value and hexavalent chromium present in the polluted water.

CO4: Analyse phosphate, SOC to determine the fertility and quality of soil.

CO5: Analyse available chlorine of a sample of bleaching powder to estimate the quality of the bleaching powder.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	2
CO2	3	2	3	2	2	2
CO3	3	2	3	2	2	2
CO4	3	2	3	2	2	2
CO5	3	2	3	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	2	2	2



03rd SEMESTER

Core 09 Code: MCH03001 Subject: Photochemistry and Pericyclic Reactions Credits: 4 [3-1-0]

Module-I (08 Hours)

Pericyclic Reactions: Molecular Orbital Symmetry, Frontier Orbitals of Ethylene, 1,3-Butadiene, 1,3,5-hexatriene and Allyl System. Classification of Pericyclic Reactions. Woodward-Hoffmann Correlation Diagrams. FMO Approach.

Electrocyclizations: Con-rotatory and Dis-rotatory Motions,

Module-II(08 Hours)

Cycloaddition Reactions: $4n$, $4n+2$ and Allyl Systems. Supra- and Antara-facial Additions, $4n$ and $4n+2$ Systems, $2+2$ Additions of Ketenes, 1,3Dipolar Cycloadditions and Cheletropic Reactions.

Module-III (08 Hours)

Sigmatropic Rearrangements: Supra and Antara-facial Shifts of H, Sigmatropic Shift of Carbon Moieties, 3,3- and 5,5- Sigmatropic Rearrangements, Claisen, Cope and aza-Cope Rearrangements. Fluxional Tautomerism. Ene Reaction.

Module-IV (08 Hours)

Photo Reactions: Introduction, Dissociation, Reduction, Isomerisation, Cycloaddition, Paterno-Buchi Reaction, Norrish Type I and II Reactions, Di-pi-methane Reaction, Photochemistry of Arenes.

Module-V (08 Hours)

Reagents in Organic Synthesis: Gilman's Reagent, Lithium Dimethyl Cuprate, Lithium Diisopropyl Amide, DCC, 1,3-Dithiane, Trimethylsilyl Iodide, Tri-n-butyl Tin Hydride, Osmium Tetroxide, Selenium Dioxide, Phase Transfer Catalysis (Crown Ether, Merrifield Resin, Wilkinson's Catalyst), Dichlorodicyano Benzoquinone (DDQ).

Books Recommended:

1. R.B. Woodward and R. Hoffman, The Conservation of Orbital Symmetry, 1st Edition, Academic Press, 1971.
2. T.L. Gilchrist and R.C. Storr, Organic reactions and orbital symmetry, 2nd Edition, Cambridge University Press, 1979.
3. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition, Pearson, 1987.
4. J.D. Roberts and M.C. Caserio, Basic Principles of Organic Chemistry, 2nd Edition, W.A. Benjamin Inc., 1977.



5. J. Singh, Photochemistry and Pericyclic Reactions, 4th Edition, New Age International, 2019

6. I. Fleming, Pericyclic Reactions, 2nd Edition, Oxford University Press, 2015.

Course Outcomes:

CO1: Define and express the different pericyclic reactions and their application in organic synthesis. Understand detailed molecular orbital investigation of pericyclic reaction mechanism including electrocyclic reaction.

CO2: Demonstrate the cycloaddition reaction and mechanism.

CO3: Evaluate and analyze sigmatropic rearrangement and application.

CO4: Construct the photochemical reactions in organic synthesis.

CO5: Apply and demonstrate the different reagents in organic synthesis

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	1
CO2	3	2	2	3	2	1
CO3	3	2	2	3	2	1
CO4	3	2	2	3	2	1
CO5	3	2	2	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	3	2	1

Core 10 Code: MCH03002 Subject: Applications of Spectroscopic Techniques Credits: 4 [3-1-0]

Module-I (08 Hours)

Electron Spin Resonance (ESR) Spectroscopy: Basic Principles, Zero Field Splitting and Kramer's Degeneracy, Factors Affecting the 'g' Value. Hyperfine Interaction and Splitting, Isotropic and Anisotropic Hyperfine Coupling Constants, Spin Hamiltonian, Spin Densities and McConnell Relationship, Measurement Techniques, Applications.

Module-II (08 Hours)

Nuclear Magnetic Resonance (NMR) Spectroscopy: General Introduction and Definition, Continuous Wave (CW) and Pulsed Fourier Transformed (FT-NMR) Technique, Rotating Frame of Reference, Chemical Shift, Shielding Mechanism, Mechanism of Measurement,



Chemical Shift Values and Correlation for Protons Bonded to Carbon (Aliphatic, Olefinic, Aldehydic, and Aromatic Compounds) and Other Nuclei (Alcohols, Phenols, Enols, Carboxylic Acids, Amines, Amides, and Mercapto), Chemical Exchange, Effect of Deuterium, Chemical Shift Equivalence, Stereochemistry, Magnetic Equivalence, Simple Spin-Spin Interaction, Pople notation, Spin System (AB and AX type). Complex Spin-Spin Interaction between Two, Three, Four and Five Nuclei (First Order Spectra), Virtual Coupling, Karplus Curve-Variation of Coupling Constant with Dihedral Angle.

Module-III(08 Hours)

Simplification of Complex Spectra, Nuclear Magnetic Double Resonance, Contact Shift Reagents.

Carbon-13 NMR Spectroscopy: General Considerations, Chemical Shift (Aliphatic, Olefinic, Alkyne, Aromatic, Heteroaromatic and Carbonyl Carbon), Nuclear Overhauser (NOE).

Resonance of Other Nuclei. Two Dimension NMR Spectroscopy – COSY, NOESY, DEPT, APT and Inadequate Techniques

Module-IV (08 Hours)

Mass Spectrometry: Introduction, Mass Spectrum, Determination of Molecular Formulae, Parent Peak, Base Peak, Use of Molecular Fragmentation, Mass Spectra of Some Classes of Compounds (Hydrocarbons, Alcohols, Phenols, Ketones, Aldehydes, Acids and Esters). Application to structure elucidation.

Module-V (08 Hours)

UV-Vis Spectroscopy: Application in Structure Elucidation of Organic Molecules

IR Spectroscopy: Application in Structure Elucidation of Organic Molecules

Problems Involving UV, IR, NMR and Mass Spectroscopy.

Books Recommended:

1. D.L. Pavia, G.M. Lampman, G.S. Kriz, and J.A. Vyvyan, Introduction to Spectroscopy, 5th Edition, Cengage Learning, 2015.
2. P.S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition, New Age International, 2007.
3. R.M. Silverstein, F.X. Webster, D.J. Kiemle, and D.L. Bryce, Spectrometric Identification of Organic Compounds, 8th Edition, John Wiley and Sons, 2014.
4. Y.R. Sharma, Elementary Organic Spectroscopy: Principles and Chemical Applications, 5th Edition, S. Chand and Sons, 2013.

Course Outcomes:



CO1: Define the basic principle, instrumentation and application of ESR, in the elucidation of structure of different compounds.

CO2: Analyze the ^1H NMR spectrum of different organic compounds from the basic concepts.

CO3: Evaluate the structure of organic compounds using the application of ^{13}C NMR and 2D NMR technique.

CO4: Analyze the mass spectra of different organic compounds and be able to conform the structure.

CO5: Deduce structure of organic compound involving UV, IR, NMR and Mass Spectroscopy data

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	3	3
CO2	3	2	1	2	3	3
CO3	3	2	2	2	3	3
CO4	3	2	1	2	3	3
CO5	3	2	2	2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	1	1

Elective I: Any one course from Basket-I/Basket-II offered by the department.

Elective II: Any one course from Basket-I/Basket-II offered by the department.

Lab 05 Code: MCHOC301 Subject: Organic Synthesis Lab Credit:2 [0 0 3]

1. Preparation of p-amino benzene from aniline.
2. Preparation of benzanilide.
3. Preparation of p-bromo aniline from acetanilide.
4. Preparation of aspirin.
5. Preparation of phenylazo-2-naphthol.
6. Preparation of acetoxime.
7. Preparation of acetanilide.



Recommended Books:

1. N.K. Vishnoi, Advanced Practical Organic Chemistry, 3rd Edition, Vikas Publishing, 2009.
2. A.I. Vogel, A.R. Tatchell, B.S. Furnis, A.J. Hannaford, P.W.G. Smith, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Prentice Hall, 1989.

Course Outcomes:

CO1: Demonstrate the preparation of p-amino benzene from aniline

CO2: Analyse and apply the basic idea to the preparation of p-bromo aniline from acetanilide.

CO3: Evaluate the structure of aspirin and phenylazo-2- naphthol.

CO4: Apply and construct acetoxime.

CO5: Deduce structure of acetanilide.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	3	3
CO2	3	2	1	2	3	3
CO3	3	2	2	2	3	3
CO4	3	2	1	2	3	3
CO5	3	2	2	2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	1	1

Lab 05 Code: MCHIC301 Subject: Industrial Lab Credit:2 [0 0 3]

Any Six from the Following

1. Water analysis: (a) Residual chlorine in town supply water (b) Ammonia content of sewage water.
2. Determination of acid value, saponification value and iodine value of different oils.
3. Determination of chlorine in bleaching powder.
4. Determination of flash point of a lubricating oil.
5. Determination of viscosity of lubricating oil.
6. Determination of aniline point of lubricating oil.



7. Determination of percentage of purity of commercially available different N, P and K fertilizer.
8. Proximate analysis of a sample of coal.
9. Determination of calorific value of a sample of coal.
10. Determination of carbon residue of an oil.
11. Determination of percentage of Fe in steel sample.
12. Determination of percentage of Chromium in Chromite ore.
13. Determination of percentage of Cu in Brass.

Course Outcomes:

CO1: Apply and evaluate the water samples.

CO2: Demonstrate the separation, purification and identification of chlorine in bleaching powder.

CO3: Define and demonstrate the flash point of a lubricating oil.

CO4: Apply the fundamental idea to demonstrate the TLC.

CO5: Demonstrate and use the different methods for identifications of percentage of Fe in steel samples.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	2
CO2	3	1	2	2	2	2
CO3	3	1	2	2	2	2
CO4	3	1	2	2	2	2
CO5	3	1	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	2	3	2	2

04th SEMESTER

Elective Paper III: Any one course from Basket-I/Basket-II offered by the department

Elective Paper IV: Any one course from Basket-I/Basket-II offered by the department

Basket-I (Organic Special)

Code: MCHOC302 Subject: Disconnection Approach in Organic Synthesis Credits: 4 [3-1-0]



Module-I(08 Hours)

Disconnection Approach: An introduction to Synthons and Synthetic Equivalents, Disconnection Approach, Functional Group Interconversions, the Importance of the Order of Events in Organic Synthesis, One Group C-X and Two Group C-X Disconnections, Chemoselectivity, Reversal of Polarity, Cyclisation Reactions, Amine Synthesis.

Module-II (08 Hours)

One Group C-C Disconnections: Alcohols and Carbonyl Compounds, Regioselectivity. Alkene Synthesis, Use of Acetylenes and Aliphatic Nitro Compounds in Organic Synthesis.

Module-III (8 Hours)

Two Group C-C Disconnections: Diels-Alder Reaction, 1,3- difunctionalised Compounds, α,β - Unsaturated Carbonyl Compounds, Control in Carbonyl Condensations, 1,5- Difunctionalised Compounds. MICHEAL Addition and Robinson Annellation.

Module-IV (08 Hours)

Protecting Groups: Principle of Protection of Alcohol, Amine, Carbonyl and Carboxyl Groups.

Module-V (08 Hours)

Ring Synthesis: Saturated Heterocycles, Synthesis of 3-, 4-, 5- and 6- Membered Rings Aromatic Heterocycles in Organic Synthesis.

Book Recommended:

1. R.O.C. Norman and J.M. Coxon, Principles of Organic Synthesis, 3rd Edition, Nelson Thornes, 1993.
2. S. Warren and P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd Edition, Wiley, 2008
3. W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, 4th edition, Cambridge University Press, 2004.
4. M.P.Saluja, Organic Synthesis, Krishna Prakashan, 2016.
5. K. Sharma, Designing Organic Synthesis, Anu Books, 2019

Course Outcomes:

CO1: Define and analyze the relationship between synthons and the appropriate chemical reagents used in the laboratory. Analyse target compounds by retrosynthetic strategy to devise suitable anionic, cationic and radical synthons.

CO2: Develop the ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to retrosynthetic analysis pertaining to One group C-C Disconnections



CO3: Develop the ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to retrosynthetic analysis pertaining to two group C-C Disconnections

CO4: Apply the fundamental idea of the protection of different groups.

CO5: Describe basic knowledge and evaluate the related to the ring synthesis.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	3	2
CO2	3	2	2	2	3	2
CO3	3	2	2	2	3	2
CO4	3	2	2	2	3	2
CO5	3	2	2	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	2	3	2

Code: MCHOC303 Subject: Supramolecular and Macromolecules Credits: 4 [3-1-0]

Module-I (08 Hours)

Host-Guest Complexation Chemistry: Basic Concepts, Molecular Recognition, Complex Formation and Host Design, Macrocycles, Clefts and Open Chain Host Structures, Thermodynamics of Multi-site Host-guest Complexation.

Module-II (08 Hours)

Non-covalent Interactions and Organic Host Guest Complexes: Ionic, Hydrogen Bonding, Cation-Pi Electron Interactions, Van der Waals, Stacking and Charge Transfer Interactions.

Module-III (08 Hours)

Ionophores for Cations and Anions: Chelate, Macrocyclic and Cryptate Effects, Complexation Selectivity, Macrocycles with Secondary Binding Sites.

Module-IV (08 Hours)

Crown Ethers: Synthesis and Use of Crown Ethers in Organic Synthesis, Binaphthyl Crown Ethers (CPK Models) in Racemic Resolution.



Cyclodextrins: Ester Hydrolysis, Model of Carbonic Anhydrase (Tabushi's Model), Micelles, Their Use in Organic Synthesis.

Module-V (08 Hours)

Selected Applications: Photoinduced Intramolecular Electron Transfer Systems, Introduction to Molecular Switches, Optical Devices, Electrochemical Devices.

Books Recommended:

1. H.-J. Schneider and A.K. Yatsimirsky, Principles and Methods in Supramolecular Chemistry, 1st Edition, John Wiley and Sons, 1999.
2. J.W. Steed and J.L. Atwood, Supramolecular Chemistry, 2nd Edition, John Wiley and Sons, 2009.
3. P.D. Beer, P.A. Gale, and D.K. Smith, Supramolecular Chemistry, Oxford University Press, 1999.
4. J.-M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, 1st Edition, John Wiley and Sons, 1995.
5. K. Ariga and T. Kunitake, Supramolecular Chemistry - Fundamentals and Applications: Advanced Textbook, 3rd Edition, Springer, 2006.
6. H. Dodziuk, Introduction to Supramolecular Chemistry, 1st Edition, Kluwer Academic, 2002.
7. F. Vögtle, F. Alfter, Supramolecular Chemistry: An Introduction, 1st Edition, John Wiley and Sons, 1991.

Course Outcomes:

CO1: To demonstrate the Molecular Recognition phenomena in host guest complexation.

CO2: To incorporate the Concept of Non-Covalent Interactions and Importance of Organic Host Guest Complexes.

CO3: To analyze the Structural features of Ionophores for Cations and Anions.

CO4: To create new Crown Ethers and Cyclodextrins based derivatives.

CO5: To demonstrate the present scenario of Chiral discrimination, Self-organization processes and applications

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	1
CO2	3	2	3	2	2	1



CO3	3	2	3	3	2	1
CO4	3	2	3	3	2	1
CO5	3	2	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	3	2	1

Code: MCHOC401 Subject: Reactions and Reagents in Organic Synthesis Credits: 4 [3-1-0]

Module-I (08 Hours)

Oxidation Reaction: Introduction: Different Oxidative Processes. Hydrocarbons- alkenes, Aromatics Rings, saturated C-H Groups (Activated and Unactivated), Alcohols, Diols, Aldehydes, Ketones, Ketals and Carboxylic Acids. Alcohols, Hydrazines and Sulphides, Oxidations with Ruthenium Tetraoxide, Iodobenzene Diacetate and Thallium (III) Nitrate.

Module-II (08 Hours)

Reduction Reaction: Introduction: Different Reductive Processes. Hydrocarbons- Alkanes, Alkenes, Alkynes and Aromatic Rings. Carbonyl Compounds- Aldehydes, Ketones, Acids and their Derivatives. Epoxides: Nitro, Nitroso, Azo and Oxime Groups, Hydrogenolysis.

Module-III (08 Hours)

Reagent Containing Phosphorus, Sulphur, Silicon or Boron: Introduction, Phosphorus Contacting Reagent, Sulphur Contacting Reagent, Silicon Contacting Reagent, Boron Contacting Reagent.

Module-IV (08 Hours)

Organic Transition Metal reagents: Principle, Preparations, Properties Applications of Titanium, Chromium, Iron, Cobalt, Rhodium, Nickel and Palladium in Organic Synthesis.

Module-V (08 Hours)

Synthesis of some Complex Molecules: Application of the Above in the Synthesis of following Compounds: Equilenin, Camphor, Longifoline, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A.

Book Recommended:

1. R.O.C. Norman and J.M. Coxon, Principles of Organic Synthesis, 3rd Edition, Nelson Thornes, 1993.
2. S. Warren and P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd Edition, Wiley, 2008



3. W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, 4th edition, Cambridge University Press, 2004.
4. M.P. Saluja, Organic Synthesis, Krishna Prakashan, 2016.
5. K. Sharma, Designing Organic Synthesis, Anu Books, 2019

Course Outcomes:

CO1: Define and express the different oxidative processes.

CO2: Demonstrate and apply the fundamental idea for different reductive processes.

CO3: Apply the knowledge and construct various reaction in presence of various reagent containing phosphorus, sulphur, silicon or boron.

CO4: Define and express ideas for organic transition metal reagents.

CO5: Describe basic knowledge and evaluate to demonstrate a few preparations of complex molecules.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	3	3
CO2	3	2	2	2	3	3
CO3	3	2	2	2	3	3
CO4	3	2	2	2	3	3
CO5	3	2	2	2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	2	3	3

Code: MCHOC402

Subject: Bioorganic Chemistry

Credits: 4 [3-1-0]

Module-I (08 Hours)

Chemistry of Carbohydrates: Structure of Polysaccharides: Starch and Glycogen, Structural Polysaccharides, Structure and Biological Functions of Glucosaminoglycans, Carbohydrate Metabolism: Photosynthesis, Glycolysis and Krebs's Cycle.

Module-II (08 Hours)

Chemistry of Lipids: Introduction and Cell membranes, Classification of Lipids, Metabolism of Lipids and Chemistry of Fatty Acids: Chemistry of Fatty Acids, biosynthesis



of Fatty Acids, Biosynthesis of Unsaturated Fatty Acids (Prostaglandins), β -oxidation of Fatty Acids, Metabolism of Sphingolipids, Phospholipids and Cholesterol.

Module-III(08 Hours)

Chemistry of Amino Acids and Proteins: Introduction, Behaviour of Proteins in Solutions, Common Amino Acids of Proteins, Classification of Amino Acids, Classification of Proteins, Primary Structure of Proteins and Its Determination, Secondary Structure Proteins (α -helix, β -Sheet Structure), Tertiary and Quaternary Structures of Proteins, Brief Idea on Collagens and Myosine, Amino Acid Metabolism: Synthesis and Degradation of Lysine and Tryptophan.

Module-IV (08 Hours)

Chemistry of Nucleic Acids: Introduction: Purine and Pyrimidines Bases, Nucleosides and Nucleotides; Primary Structure and Its Method of Determination; Secondary Structures of DNA and RNA and their Comparison; Optical Properties of Nucleic Acids; Role of DNA in Protein Synthesis: Replication, Transcription and Translation; Brief Idea on Genetic Code.

Module-V (08 Hours)

Mechanisms in Biological Chemistry: Nature's Oxidizing Agent (NAD^+), Nature's Reducing Agent (NADH), ATP, ADP, PhosphoenolPyruvate, Function of Haemoglobin, DNA Synthesis

Books Recommended:

1. D.L. Nelson and M.M. Cox, Lehninger Principles of Biochemistry, 8th Edition, W.H. Freeman, 2021.
2. E.E. Conn, P.K. Stumpf, G. Bruening, and R.Y. Doi, Outlines of Biochemistry, 5th Edition, John Wiley and Sons, 2006.
3. J.M. Berg, J.L. Tymoczko, G.J. Gatto Jr., and L. Stryer, 8th Edition, W.H. Freeman, 2015.
4. D. Voet, J.G. Voet, and C.W. Pratt, Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, John Wiley and Sons, 2016.
5. I. Bertini, H.B. Gray, S. Lippard, and J. Valentine, Bioinorganic Chemistry, University Science Books, 1994.
6. V.W. Rodwell, D. Bender, K.M. Botham, P.J. Kennelly, P.A. Weil, Harper's Illustrated Biochemistry 31st Edition, McGraw-Hill, 2018.

Course Outcomes:

CO1: Evaluation and application of advanced carbohydrate chemistry

CO2: Evaluation and application of lipids

CO3: Evaluation and application of biochemistry of amino acids and proteins



CO4: Evaluation and application of biochemistry of nucleic acids

CO5: Evaluation and application of biological catalysts and processes

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	0	3	1	1	3
CO2	3	0	3	1	0	3
CO3	3	0	3	1	1	3
CO4	3	0	3	1	1	3
CO5	3	0	3	1	0	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	0	3	1	1	3

Code: MCHOC403

Subject: Ring Synthesis

Credits: 4 [3-1-0]

Module-I (08 Hours)

Non-aromatic Heterocyclics: Synthesis and Importance of the following Ring Systems, Azirines, Aziridines, Oxiranes, Thiiranes, Diazirenes, Diaziridines, Oxaziridines, Azetidines, Oxetanes, and Thietanes.

Module-II (08 Hours)

Nomenclature of Heterocyclic Compounds of Bicyclic/Tricyclic (5-6 Membered) fused Heterocycles (up to Three Hetero Atoms). (Common, Systematic (Hantzsch-Widman), and Replacement Nomenclature) Synthesis and Reactions of Coumarins, Quinoxalines, Cinnolines, Indole, Benzimidazoles, Benzoxazoles, Benzothiazoles, Purines and Acridines.

Module-III (08 Hours)

Five and Six membered Heterocyclics with Two Hetero Atoms: Synthesis, Aromatic Character and Importance of the following Heterocycles: Pyrazole, Imidazole, Oxazole, Thiazole, Isoxazole, Isothiazole, Pyridazine, Pyrimidine. Pyrazine, Oxazine, thiazine, benzimidazole, benzoxazole, and benzthiazole.

Module-IV (08 Hours)

Heterocyclics with More than Two Hetero Atoms: Synthesis, Aromatic Character and Importance of the following Heterocycles: 1,2,3-Triazoles, 1,2,4-Triazoles, Tetrazoles, 1,2,4-Oxadiazole, 1,3,4-Oxadiazole, 1,2,5-Oxadiazole, 1,2,3-Thiadiazoles, 1,3,4-Thiadiazoles,



1,2,5-Thiadiazoles, 1,2,3-Triazine, 1,2,4-Triazine, 1,3,5-Triazine, Tetrazines. Synthesis and Importance of Purines and Pteridines. Synthesis of Caffeine, Theobromine and theophylline.

Module-V (08 Hours)

Larger Ring and other Heterocycles: Synthesis and Structure of Azepines, Oxepines and Thiopines. Synthesis of Diazepines Rearrangements of 1,2-Diazepines. Synthesis of Benzoazepines, Benzodiazepines, Benzooxepines, Benzothiepinines, Azocines and Azonines. Synthesis of selenophenes, Tellurophenes, Phospholes, and Boroles.

Books Recommended:

1. K.B.G. Torssell, Natural Product Chemistry: A Mechanistic, Biosynthetic and Ecological Approach, 1st Edition, Torssell Swedish Pharmaceutical Press, 1997.
2. S.V. Bhat, B.A. Nagasampagi, and S. Meenakshi, Natural Products: Chemistry and Applications, 2nd Edition, Narosa Publishing, 2006.
3. O.P. Agarwal, Organic Chemistry Natural Products, Volume-II, 41st Edition, Krishna Prakashan, 2014.
4. K.W. Bentley, The Chemistry of Natural Products, Volume I-IV, Interscience Publishers, 1957.
5. K. Nakanishi, T. Goto, S. Itô, S. Natori, and S. Nozoe, Natural Products Chemistry, Volume-I, 1st Edition, Academic Press, 1974.
6. L.A. Paquette, Principles of Modern Heterocyclic Chemistry, 1st Edition, W.B. Benjamin, 1968.
7. R.M. Acheson, An Introduction to the Chemistry of Heterocyclic Compounds, 1st Edition, John Wiley & Sons, 1976.
8. K.C. Nicolaou and E.J. Sorensen, Classics in Total Synthesis: Targets, Strategies, Methods, 1st Edition, Wiley-VCH, 1996.
9. P.S. Kalsi, Spectroscopy of Organic Compounds, 7th Edition, New Age International, 2016.
10. K. Faber, Biotransformations in Organic Chemistry, 5th Edition, Springer-Verlag, 2004.
11. E. Pretsch, P. Bühlmann, and C. Affolter, Structure Determination of Organic Compounds, 4th Edition, Springer-Verlag, 2009.

Course Outcome:

CO1: To demonstrate the synthesis of five and six-member heterocyclic compounds with two or more heteroatoms.

CO2: To design new larger ring heterocyclic compounds.



CO3:To create new methodologies in synthesizing five and six- member heterocyclic compounds with two or more heteroatoms.

CO4:To demonstrate the synthesis of larger ring heterocyclic compounds.

CO5:To develop advanced synthetic routes for organic compounds.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	3	2	3
CO2	2	3	2	3	2	3
CO3	2	3	2	3	2	3
CO4	2	3	2	3	2	3
CO5	2	3	2	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	2	3	2	3

Basket-II (Industrial Special)

Code: MCHIC302 Subject: Analytical Chemistry Credits: 4 [3-1-0]

Module-I (10 Hours)

Reliability of Analytical Data: Errors in Chemical Analysis, Classification of Errors, Significant Figures, Precision And Accuracy, Methods of Expressing Accuracy, Absolute Error and Relative Error, Methods of Expressing Precision, Average Deviation, Standard Deviation, Confidence Limits, Median Value, Range, Coefficient of Variation.

Module-II (06 Hours)

Sampling in Analysis: Definition, Theory of Sampling, Technique of Sampling, Statistical Criteria of Good Sampling and Required Size, Stratified Sampling, Transition and Storage Samples.

Module-III (08 Hours)

Solvent Extraction: Basic Principles, Classification of Extraction, Mechanism of Extraction, Extraction Equilibria, Technique of Extraction, Applications in Analytical Chemistry.

Ion Exchange: Synthesis and Characteristics of Ion Exchange, Ion Exchange Equilibria, Technique of Ion Exchange, Application of Ion Exchange for Separation.

Module-IV (08 Hours)



Ultraviolet and Visible Spectrophotometry: Introduction, Nature of Absorbing Species, Visual Colorimetry, Photoelectric Cell and Filters, Photoelectric Filter Photometry, Errors in Photoelectric Photometry, Spectrophotometry, Working of Spectrophotometer, Simultaneous Spectrophotometry, Differential Spectrophotometry, Reflectance Spectrophotometry, Photometric Titrations, Composition of Colored Complex Sandell's Sensitivity, Relative Concentration and Ringbon's Plot.

Atomic Fluorescence Spectrometry: Theory, Instrumentation and Applications.

X-ray Methods: X-ray Absorption and X-ray Diffraction.

Module-V (08 Hours)

Electron Spectroscopy: Photoelectron Spectroscopy (PES), Auger Electron Spectroscopy (AES), X-ray Photoelectron Spectroscopy or Electron Spectroscopy for Chemical Analysis (ESCA).

Electron Microscopy: Scanning Electron Microscope (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM).

Books Recommended:

1. D.A. Skoog, F.J. Holler, and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition, Saunders College Publishing, 1998.
2. D.A. Skoog, F.J. Holler, and S.R. Crouch, Principles of Instrumental Analysis, 6th Edition, Cengage Learning, 2006.
3. P. Kissinger and W.R. Heineman, Laboratory Techniques in Electroanalytical Chemistry, 2nd Edition, Marcel Dekker, 1996.
4. H.A. Mottola, Kinetic Aspects of Analytical Chemistry (Chemical Analysis: A Series of Monographs on Analytical Chemistry and Its Applications), John Wiley and Sons, 1988.
5. J. Tölgyessy and M. Kyrš, Radioanalytical Chemistry, Volume I and II, Ellis Horwood, 1989.
6. D.A. Skoog, D.M. West, F.J. Holler, and S.R. Crouch, Fundamentals of Analytical Chemistry, 9th Edition, Brooks/Cole, 2013.

Course Outcomes:

CO1: Apply different methods to enhance precision and accuracy of analytical data.

CO2: Implement sampling methods to enhance precision and accuracy.

CO3: Apply of separation techniques to separate metals.

CO4: Analyze data obtained from spectrochemical techniques to calculate unknown concentrations, to obtain structural information and spectrophotometric accuracy.



CO5: Application of electron spectroscopy and microscopy methods to obtain information regarding surface.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	2	2	3	3	2
CO3	3	3	2	3	3	3
CO4	3	3	2	3	3	3
CO5	3	3	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	3

Code: MCHIC303

Subject: Industrial Process

Credits: 4 [3-1-0]

Module-I (08 Hours)

Petroleum and Coal based Chemicals: Composition of Petroleum, Cracking Processes, Commercial Production of Ethylene, Acetylene, and Distillation of Coal.

Module-II (10 Hours)

Oil based Industries: Oils and Fats: Solvent Extraction of Oils, Hydrogenation of Oil, and Use of Oil in the Manufacturing of Soap, Paints and Varnishes.

Surface Active Agents: Classification and Manufacturing of Detergents used for Cleansing Purpose.

Fermentation Industries: A General Discussion on Fermentation Conditions, Manufacturing of Penicillin.

Module-III (06 Hours)

Pesticides and Pharmaceutical Industries: DDT Manufacture, BHC Manufacture, 2,4-D Manufacture, Parathion Manufacture, Pharmaceutical Industry.

Module-IV (06 Hours)

Fuel Cells: General Chemistry of Fuel, Hydrogen-Oxygen Fuel Cell, Hydrocarbon-Oxygen Fuel Cell, Carbon Monoxide Fuel Cell, Methyl Alcohol Fuel Cell, Efficiency of Fuel Cell

Module-V (10 Hours)



Liquid Crystals: Mesomorphic Behaviour, Thermotropic Liquid Crystals, Nematic and Smectic Mesophases. Optical and Dielectric Properties of Liquid Crystals. Lyotropic Phases and Their Description of Ordering.

Books Recommended:

1. M.G. Rao and M. Sittig, Dryden's Outlines of Chemical Technology, 3rd Edition, East-West Press, 1997.
2. M.G. Rao and M. Sittig, Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, East-West Press, 2010.
3. B.K. Sharma, Industrial Chemistry, 49th Edition, Goel Publishing, 2013.
4. A. Jess, U. Kragl, and P. Wasserscheid, Chemical Technology: An Integral Textbook, 1st Edition, John Wiley and Sons, 2013.
5. G.N. Pandey, Textbook of Chemical Technology, 2nd Edition, Sangam Books, 2000.
6. S. Singh, Liquid Crystals: Fundamentals, 1st Edition, World Scientific, 2002.

Course Outcomes:

CO1: Develop knowledge about petroleum and coal based industries.

CO2: Describe working principle and instrumentation of oil based, fermentation and surface active industries.

CO3: Synthesis and application of various pesticides.

CO4: Apply concept and working of fuel cell.

CO5: Develop understanding of liquid crystal.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	3	3	3	3
CO3	3	2	3	2	3	2
CO4	3	2	2	2	3	3
CO5	3	3	3	3	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	3	3

Code: MCHOC304/MCHIC304 Subject: Chemical Kinetics and Physical Photochemistry Credits: 4 [3-1-0]



Module-I (08 Hours)

Chemical Kinetics: Complex Reactions – Opposing, Parallel and Consecutive Reactions, Mechanism of Reaction: Chain Reactions –Linear Reactions, Branching Chains – Explosion Limits; Rice Herzfeld Scheme, Theories of Reaction Rates: Collision Theory, Potential Energy Surfaces (Basic Idea), Transition State Theory (both Thermodynamic and Statistical Mechanics Formulations), Theory of Unimolecular Reactions, Lindemann Mechanism, Hinshelwood Treatment, RRKM Model (Qualitative Treatment).

Module-II (06 Hours)

Solution Kinetics: Factors Affecting Reaction Rates in Solution, Effect of Solvent and Ionic Strength (Primary Salt Effect) on the Rate Constant, Secondary Salt Effects, Isotope Effect, Kramer's Theory, Diffusion Limited Reactions, Study of Fast Reactions using Stopped Flow and Relaxation Techniques.

Module-III (08 Hours)

Transport Phenomena: Diffusion Coefficients, Fick's First and Second Laws, Relation between Flux and Viscosity, Relation between Diffusion Coefficient and Mean Free Path, Relation between Thermal Conductivity/Viscosity and Mean Free Path of a Perfect Gas, Einstein Relation, Nernst-Einstein Equation, Stokes-Einstein Debye Equation (SED), Einstein-Smoluchowski Equation.

Module-IV (08 Hours)

Surface Phenomena: Amphiphilic Molecules and Surface Active Agents, Classification of Surface Active Agents, Micellization, Hydrophobic Interaction, Critical Micelle Concentration (CMC), Krafft Temperature, Factors Affecting the CMC of Surfactants, Counter Ion Binding to Micelles, Thermodynamics of Micellization, Solubilization, Microemulsions, Reverse Micelles, Surface Films (Electrokinetic Phenomena), Catalytic Activity at Surfaces.

Module-IV (10 Hours)

Physical Photochemistry: Franck-Condon Principle, Laws of Photochemical Equivalence, Unimolecular Photophysical Processes: Vibronic Transitions, Kasha's Rule, Fluorescence and Phosphorescence, Internal Conversion, Intersystem Crossing. Mirror Symmetry Relationship, Fluorescence Life Time, Quantum Yields of Various Processes. Bimolecular Photophysical Processes: Photoinduced Electron Transfer and Charge Transfer Processes, Excimer and Exiplex, Fluorescence Quenching, Radiative, Forster Type and Dexter Type Energy Transfer.

Books Recommended:



1. K. J. Laidler, Chemical Kinetics, 3rd Edition, Pearson Education, 2003.
2. D.A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, 1st Edition, University Science Books, 1997.
3. K.K. Rohatgi-Mukharjii, Fundamentals of Photochemistry, 1st Edition, John Wiley and Sons, 1978.
4. P. Atkins and J. de Paula, Physical Chemistry, 9th Edition, W.H. Freeman, 2002.
5. J.G. Calvert and J.N. Pitts, Jr., 1st Edition, Photochemistry, John Wiley and Sons, 1966.
6. J.R. Lakowicz, Principles of Fluorescence Spectroscopy, 3rd Edition, Springer, 2006.

Course Outcomes:

CO1: Study the chemical kinetics of complex and chain reactions, and theories of reaction rates.

CO2: Analyze the rate of the chemical reaction in solutions.

CO3: Discuss the transport phenomena of the physical processes.

CO4: Express and evaluate the surface phenomena of the physical processes.

CO5: Apply the interaction of matter with wave to demonstrate the phenomena of Physical Photochemistry.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	2	2	2	2	2	2
CO3	3	3	2	2	3	3
CO4	3	3	2	2	3	3
CO5	3	3	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	3	3

Code: MCHOC305/MCHIC305 **Subject:** Environmental Chemistry and Management **Credits:** 4 [3-1-0]

Module-I (08 Hours)

Fundamentals of Environment and Ecology: Environment Definition, Environmental Segments, Concepts of Ecosystem: Fundamentals of Ecology and Ecosystem, Components of Ecosystem, Food Chain, Food Web, Trophic Level, Energy Flow. Introduction, Types,



Characteristic Features, Structure and Function of the following Ecosystem: Forest, Grassland, Desert and Aquatic Ecosystem. Effects of Human Activities on Environment: Agriculture, Housing, Industry, Mining and Transportation Activities, Basics of Environmental Impact Assessment and Sustainable Development.

Natural Resources: Water Resources - Availability and Quality aspects. Mineral Resources, Soil, Material Cycles- Carbon, Nitrogen and Sulphur Cycles. Energy - Different Types of energy, Conventional and Non-conventional Sources - Hydro Electric, Fossil Fuel based, Nuclear, Solar, Biomass and Geothermal Energy and Bio-gas. Gas Hydrates, Hydrogen as an Alternative Future Source of Energy.

Module-II (08 Hours)

Environmental Pollution and Current Environmental Issues of Importance: Definition, Causes, Effects, and Control Measures of: Air Pollution, Water Pollution, Land Pollution, Noise Pollution. Climate Change and Global Warming: Effects, Acid Rain, Ozone Layer Depletion, Photochemical Smog, Solid Waste Management, Waste Water Treatment.

Module-III (08 Hours)

Environment Quality Standards: Ambient Air Quality Standards, Water Quality Parameters and Standards; Turbidity, p^H , Suspended Solids, Hardness, Residual Chlorine, Sulfates, Phosphates, Iron and Manganese, DO, BOD, COD.

Instrumental Methods for monitoring Pollutants: Modern Techniques used in Analysis, Conductometric Analyzer, Atomic Absorption Spectroscopy, Nephelometry, and Turbidimetry, Determination of Disinfectants, Determination of Pesticides, Microbial Methods of Estimation.

Module-IV (08 Hours)

Basic Concepts of Environmental Impact Assessment (EIA): Preparation of Environmental Base Map, Classification of Environmental Parameters – Environmental Setting – Environmental Indicators.

EIA Methodologies: Introduction, Criteria for the Selection of EIA Methodology, Categorization of Methodologies, Matrix Methods, Network Method, Environmental Media Quality Index Method, Cost/Benefit Analysis.

Methodology for the Assessment of Impacts of Some Attributes: Surface Water, Air and Biological Environment. Methodology and Generalized Approach for the Assessment of Impact of Development Activities on Vegetation and Wildlife, Environmental Impact of Deforestation and Incorporation of Mitigation Measures.

Module-V (08 Hours)



Environmental Audit and Legal Aspects: Environmental Audit and Environmental Legislation. Objectives of Environmental Audit, Types of Environmental Audit, Audit Protocol, Stages of Environmental Audit, Onsite Activities, Evaluation of Audit Data and Preparation of Audit Report – Legal Aspects – Case Studies.

Books Recommended:

1. B.K. Sharma and H. Kaur, Environmental Chemistry, 1st Edition, Goel Publishing, 1995.
2. A.K. De, Environmental Chemistry, 9th Edition, New Age International, 2018.
3. Instrumental method of Analysis by B.K. Sharma, Goel Publishing House.
4. S.S. Dara and D.D. Mishra, A Test Book of Environmental Chemistry and Pollution Control, 7th Edition, S. Chand and Company, 2004.
5. S.K. Banerji, Environmental Chemistry, 2nd Edition, Prentice Hall, 1999.
6. L.W. Canter, Environmental Impact Assessment, 2nd Edition, McGraw-Hill, 1995.
7. R.K. Jain, L.V. Urban, and G.S. Stracy, Environmental Impact Analysis: A New Dimension in Decision Making. 2nd Edition, Van Nostrand Reinhold, 1981.
8. Y. Anjaneyulu and V. Manickam, Environmental Impact Assessment Methodologies, 2nd Edition, CRC Press, 2011.
9. J.G. Rau and D.C. Wooten, Environmental Impact Analysis Handbook, 1st Edition, McGraw-Hill, 1979.
10. UNESCO, Methodologies, Guidelines for the Integrated Environmental Evaluation of Water Resources Development, UNESCO/UNEP, Paris, 1987.

Course Outcomes:

CO1: Develop the concept of environment and ecology.

CO2: Define the environmental pollution and express the current environmental issues of importance.

CO3: Analyze the environment quality standards and monitor the environmental pollutants using instrumental methods.

CO4: Implement the environmental impact assessment and organize the methodologies for the assessment of impacts of some attributes.

CO5: Implement the environmental audit and legal aspects to spread the awareness for controlling the pollution.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	3



CO2	2	3	3	2	2	3
CO3	2	3	3	2	2	3
CO4	2	3	3	2	2	3
CO5	2	3	3	2	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	3	2	2	3

Code: MCHIC401 Subject: Chemistry of Materials Credits: 4 [3-1-0]

Module-I(10 Hours)

Glasses, Ceramics, Clay and Refractories: Glassy State, Glass Formers and Glass Modifiers, Applications. Ceramic Structures, Mechanical Properties, Clay Products. Refractories, Characterizations, Properties and Applications.

Module-II(10 Hours)

Composites, and Nanomaterials: Macroscopic Composites, Dispersion-Strengthened and Particle-Reinforced, Fibre-Reinforced Composites, Macroscopic Composites. Nanocrystalline Phase, Preparation, Procedures, Special Properties, Applications.

Module-III(05 Hours)

Ionic Conductors: Types of Ionic Conductors, Mechanism of Ionic Conduction, Interstitial Jumps (Frenkel), Vacancy Mechanism, Diffusion Superionic Conductors, Phase Transition and Mechanism of Conduction in Superionic Conductors, Examples and Applications of Ionic Conductors.

Module-IV(10 Hours)

Organic Solids, Fullerenes, and Molecular Devices: Conducting Organics, Organic Superconductors, Magnetism in Organic Materials. Fullerenes-Doped, Fullerenes as Superconductors. Molecular Rectifiers and Transistors, Artificial Photosynthetic Devices, Optical Storage Memory and Switches-Sensors. Nonlinear Optical Materials: Nonlinear Optical Effects, Second and Third Order, Molecular Hyperpolarisability and Second Order Electric Susceptibility, Materials for Second and Third Harmonic Generation.

Module-V(05 Hours)



Thin Films and Langmuir-Blodgett Films: Preparation Techniques, Evaporation/Sputtering, Chemical Processes, Sol-Gel, etc. Langmuir-Blodgett (LB) Film, Growth Techniques, Photolithography, Properties and Application of Thin and LB Films.

Books Recommended:

1. N.W. Ashcroft and N.D. Mermin, Solid State Physics, 33rd Edition, Holt, Rinehart and Winston, 1976.
2. W.D. Callister and D.G. Rethwisch, Materials Science and Engineering: An Introduction, 9th Edition, John Wiley and Sons, 2014.
3. H.V. Keer, Principles of Solid State, 1st Edition, New Age International, 1993.
4. J.C. Anderson, K.D. Leaver, R.D. Rawlings, and J.M. Alexander, Materials Science, 4th Edition, Springer, 2013.
5. G.W. Gray, Thermotropic Liquid Crystals, 1st Edition, John Wiley and Sons, 1987.
6. H. Kelker and R. Hatz, Handbook of Liquid Crystals, 1st Edition, Verlag Chemie, 1980.
7. D. Singh, D. Zhu, W.M. Kriven, S. Mathur, H.-T. Lin, Design, Development, and Applications of Structural Ceramics, Composites, and Nanomaterials, 1st Edition, John Wiley and Sons, 2014.
8. C.S. Sunandana, Introduction to Solid State Ionics: Phenomenology and Applications, 1st Edition, CRC Press, 2016.
9. T. Torres and G. Bottari, Organic Nanomaterials: Synthesis, Characterization, and Device Applications, 1st Edition, John Wiley and Sons, 2013.
10. M. Ohring, Materials Science of Thin Films: Deposition and Structure, 2nd Edition, Academic Press, 2002.
11. F. Mohammad, Specialty Polymers: Materials and Applications, 1st Edition, I.K. International, 2007.

Course Outcomes:

CO1: Evaluation and application of chemical materials in day-to-day life.

CO2: Evaluation and application of macro and nano composites.

CO3: Evaluation and application of Ionic conductors.

CO4: Evaluation and application of organic super conductors and organic electronics.

CO5: Evaluation and application of Thin Films and Langmuir-Blodgett Film and related concepts.

Course Articulation Matrix

PO1	PO2	PO3	PO4	PO5	PO6
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CO1	3	0	1	1	0	1
CO2	3	3	3	3	2	3
CO3	1	1	2	3	2	3
CO4	0	0	3	3	2	3
CO5	1	3	2	3	0	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	1	2	3	1	3

Code: MCHIC402 Subject: Materials and Energy Balance Credits: 4 [3-1-0]

Module-I (10 Hours)

Material Balances Without Chemical Reactions: Process Flow-Sheet, Material Balances, Recycling Operations, Material Balances of Unsteady State Operations.

Module-II (08 Hours)

Material Balances Involving Chemical Reactions: Definition of Terms, Electrochemical Reactions, Recycling, Parallel and Bypassing Operations, Metallurgical Applications

Module-III (08 Hours)

Energy Balances: Energy and Thermo-Chemistry, Energy Balances, Heat Capacity, Heat Capacity of Gases at Constant Pressure, Sensible Heat Changes in Liquids, Heat Capacity of Gaseous Mixtures, Latent Heats, Enthalpy Changes During Phase Transfers Accompanied by Sensible Heat Changes, Enthalpy Changes Accompanying Chemical Reactions,

Module-IV (06 Hours)

Effect of Temperature on Heat of Formation, Heat of Reaction, Adiabatic Reactions, Effect of Pressure on Heat of Reaction, Thermochemistry of Mixing Process, Dissolution of Solids, Liquid-Liquid Mixtures, Heat of Solution by Partial Molal Quantities

Module-V(08 Hours)

Stoichiometry and Unit Operations: Distillation, Absorption and Stripping, Extraction and Leaching, Crystallisation, Psychrometry, Drying, Evaporation, Less Conventional Operation.

Books Recommended:

1. G.V. Reklaitis, Introduction to Material and Energy Balances, 1st Edition, John Wiley and Sons, 1983.



2. A.E. Morris, G. Geiger, and H.A. Fine, Handbook on Material and Energy Balance Calculations in Material Processing, 3rd Edition, John Wiley and Sons, 2011.
3. C. Oloman, Material and Energy Balances for Engineers and Environmentalists, 3rd Edition, Imperial College Press, 2009.
4. V.V. Veverka and F. Madron, Material and Energy Balancing in the Process Industries: From Microscopic Balances to Large Plants, 1st Edition, Elsevier, 1997.
5. B.I. Bhatt and S.B. Thakore, Stoichiometry, 5th Edition, Tata McGraw-Hill, 2010.
6. F.A. Cotton and G. Wilkinson, C.A. Murillo, and M. Bochmann, Advanced Inorganic Chemistry, 6th Edition, John Wiley and Sons, 2009.

Course Outcomes:

CO1: Apply the concept of general stoichiometry and mass balance to solve industrial problems without involving chemical reactions.

CO2: Solve problems related to industries involving chemical reactions.

CO3: Apply energy balance to solve problems related to various operations of chemical industries.

CO4: Analyze the effect of temperature and pressure on industrial processes.

CO5: Recognize unit operations involved in industries and finding solutions to the problems

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	2	3	2	3
CO4	3	2	2	2	3	3
CO5	3	3	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	3

Code: MCHIC403 Subject: Colloids and Surface Chemistry Credits: 4 [3-1-0]

Module-I (08 Hours)

Fundamental Concept of Phase, Component, Degrees of Freedom, Phase Rule, One Component System (Water, Sulphur System), Condense Phase Rule, Two Component



System (Lead-Silver, Iron-Carbon system), Three Component Systems of both Solids and Liquids, Application and limitation of Phase rule.

Module-II (08 Hours)

Surface Tension, Capillary Action, Adsorption, Types of Adsorption, Application of Adsorption, Factors Influencing Adsorption, Desorption Activation Energy, Heat of Adsorption, Estimation of Surface Areas of Solids from Solution Adsorption Studies.

Module-III (08 Hours)

Gibbs Adsorption Isotherm, Freundlich's Adsorption Isotherm, Langmuir's Adsorption Isotherm and its Limitations, BET Adsorption Isotherm and its Applications, Derivation of Langmuir Isotherm from BET Isotherm equation.

Module-IV (08 Hours)

Surface Active Agents, Classification of Surface Active Agents, Concepts on Micelle, Micellization, Hydrophobic Interaction, Critical Micellar Concentration (CMC), Kraft Temperature, Factors Affecting the CMC of Surfactants, Thermodynamics of Micellization, Phase Separation and Mass Action Models, Solubilization, Microemulsion, Reverse Micelles.

Module-V (08 Hours)

Colloidal State: Introduction; Classification of Colloids, Preparation and Purification of Colloidal Systems, Properties of Colloidal Solutions, Tyndall Effect, Coagulation of Colloidal Sols, Determination of Size of Colloidal Particles.

Books Recommended:

1. K.L. Kapoor, A Textbook of Physical Chemistry, Volume I-IV, 3rd Edition, Macmillan, 2012.
2. D.N. Bajpai, Advanced Physical Chemistry, 2nd Edition, S. Chand and Sons, 2001.
3. S.K. Dogra and S. Dogra, Physical Chemistry through Problems, 2nd Edition, New Age International, 2015.
4. D.V.S. Jain and S.P. Jauhar, Physical Chemistry: Principles and Problems, 1st Edition, Tata McGraw-Hill, 1988.
5. R.M. Pashley, and M.E. Karaman, Applied Colloid and Surface Chemistry, John Wiley and Sons, 2004.
6. A.W. Adamson and A.P. Gast, Physical Chemistry of Surfaces, 6th Edition, Wiley-InterScience, 1997.
7. P.C. Hiemen and R. Rajgopal, Principle of Colloid and Surface Chemistry, Marcel Dekker, 1997.



8. D.J. Shaw, Introduction to Colloid and Surface Chemistry, 4th Edition, Butterworth-Heineman, 2013.
9. M. J. Rosen, J.T. Kunjappu, Surfactant and Interfacial Phenomena, 4th Edition, John Wiley and Sons, 2012.

Course Outcomes:

CO1: To demonstrate the phase behaviour of liquid, solid systems.

CO2: Analyze the adsorption process in gas-liquid-solid surfaces; surface tensions and capillary action.

CO3: Construct and explain the adsorption isotherms, their limitations and applications.

CO4: To design new surfactants, micelles, micro-emulsions, reverse micelle and micellization processes.

CO5: To demonstrate and synthesize the colloids in detail, their preparation, purification, properties.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	2
CO2	3	2	3	2	2	2
CO3	3	2	3	3	2	2
CO4	3	2	3	3	2	2
CO5	3	2	3	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	3	2	2

Code: MCHIC404

Subject: Computational Chemistry

Credits: 4 [3-1-0]

Module-I (10 Hours)

Approximation Methods in Quantum Mechanics-I: Many-body Problem and Need of Approximation Methods, Independent Particle Model. Variation Method: Variation Theorem with Proof, Illustration of Variation Theorem using the Trial Function $\chi(a-x)$ for Particle in a 1D-Box and using the Trial Function $e^{-\alpha r}$ for the Hydrogen Atom, Variation Treatment for 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 Ground State of the Helium Atom, Qualitative Idea of Hellmann-Feynman Theorem.

Module-II (08 Hours)

Approximation Methods in Quantum Mechanics-II: Hartree-Fock Method, Multi-electron Atoms, Hartree-Fock Equations (No Derivation), Fock Operator, Core Hamiltonian, Coulomb Operator and Exchange Operator, Qualitative Treatment of Hartree-Fock Self-Consistent Field (HFSCF) Method. Roothaan's Concept of Basis Functions, Slater Type Orbitals (STO) and Gaussian Type Orbitals (GTO), Sketches of STO and GTO.

Module-III (06 Hours)

Introduction to Computer and Computing: Basic Structure and Functioning of a Computer (with Demonstration), Algorithm, Flowchart, Development of Small Computer Codes (in FORTRAN or C) involving Simple Formula in Chemistry such as Van der Waal's Equation, p^H , Kinetics and Radioactive Decay.

Module-IV (08 Hours)

Computational Quantum Chemistry-I: Introduction and Scope of Computational Chemistry, Potential Energy Surface, Conformational Search, Global Minimum, Local Minima, and Saddle Points. Ab Initio Methods: A review of Hartree-Fock Method, Self-consistent Field (SCF) Procedure, Roothaan Concept Basis Functions, Basis Sets and Its Classification: Slater Type and Gaussian Type Basis Sets, Minimal Basis Set, Pople Style Basis Sets, Hartree-Fock Limit. Post Hartree-Fock Methods - Introduction to Møller-Plesset Perturbation Theory, Configuration Interaction, Coupled Cluster and Semi Empirical Methods.

Module-V (08 Hours)

Computational Quantum Chemistry-II: Introduction to Density Functional Theory (DFT) Methods: Hohenberg-Kohn Theorems, Kohn-Sham Orbitals, Exchange Correlation Functional, Local Density Approximation, Generalized Gradient Approximation, Hybrid Functional (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 General Atomic and Molecular Electronic Structure System (GAMESS)/Firefly Input File, Single Point Energy Calculation, Geometry Optimization, Constrained Optimization and Frequency Calculation. Koopmans' Theorem.



Books Recommended:

1. I.N. Levine, Quantum Chemistry, 7th Edition, Pearson Education, 2016.
2. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 5th Edition, Oxford University Press, 2012.
3. D.A. McQuarrie, Quantum Chemistry, 2nd Revised Edition, University Science Books, 2007.
4. R.K. Prasad, Quantum Chemistry, 4th Edition, New Age Science, 2009.
5. T. Engel, Quantum Chemistry and Spectroscopy, 3rd Edition, Pearson Education, 2012.
6. K.I. Ramachandran, G. Deepa, and K. Namboori, Computational Chemistry and Molecular Modeling: Principles and Applications, 1st Edition, Springer, 2008.
7. A. Hinchliffe, Molecular Modelling for Beginners, 2nd Edition, John Wiley and Sons, 2008.
8. C.J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Edition, John Wiley and Sons, 2004.
9. D.C. Young, Computational Chemistry: A Practical Guide for Applying Techniques to RealWorld Problems, 1st Edition, John Wiley and Sons, 2001.

Software Recommended:

1. Molecular Dynamics (MD) Simulation Packages: Arguslab, Tinker, NAMD, DLPOLY, CHARMM, and AMBER.
2. Ab Initio, Semi Empirical and DFT: (a) Firefly/PC GAMESS available from <http://classic.chem.msu.su/gran/gamess/> and (b) WINGAMESS available from <http://www.msg.ameslab.gov/gamess/>
3. Graphical User Interface (GUI): (a) Gabedit available from <http://gabedit.sourceforge.net/> and (b) wxMacMolPlt available from <http://www.scl.ameslab.gov/MacMolPlt>

Course Outcomes:

CO1: Demonstrate the Approximation Methods such as Variation and Perturbation Methods in Quantum Mechanics.

CO2: Application of Hartree-Fock Method in Quantum Mechanics.

CO3: Development of Computer and Computing in Quantum Mechanics.

CO4: Plan and Implementation of Ab Initio Methods in Computational Quantum Chemistry.

CO5: Development and incorporation of Density Functional Theory (DFT) in Computational Quantum Chemistry.

Course Articulation Matrix



	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	1
CO2	3	3	2	3	3	1
CO3	3	3	2	3	3	1
CO4	3	3	2	3	3	1
CO5	3	3	2	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	3	1

Code: MCHOE904

Subject: Fuel and Energy

Credits: 4 [3-1-0]

Module-I (08 Hours)

Solid Fuel: Classification and Analysis of Coal, Gasification and Liquefaction Coal, Bomb Calorimeter, Storage and Handling of Coal.

Liquid fuel: Origin and Classification of Petroleum, Liquid Fuel from other Sources.

Module-II (08 Hours)

Gaseous Fuel: Natural Gas, Producer Gas, Water Gas, Refinery Gas, LPG,CNG, Methane from Coal Mines, Handling of Gaseous Fuels, Combustion Calculations based on Solid, Liquid, and Gaseous Fuels.

Module-III (08 Hours)

Renewable Energy Sources: Solar Energy: Principle of Conversion of Solar Energy to Heat, Storage System, Solar Photovoltaic Cell, Solar Pumps, Refrigerators

Hydrogen Energy: Production of Hydrogen from Fossil Fuels, Thermal Decomposition, Photocatalytic Methods, Hydrogen Storage in Metal Hydrides, Merits of Hydrogen as Fuel.

Module-IV (08 Hours)

Fuel Cell: Hydrogen-Oxygen Fuel Cell, Alkaline Fuel Cell, Polymer Electrolyte Fuel Cell, Thermodynamics of Fuel Cells.

Module-V (08 Hours)

Nuclear Fuels: Principles, Nuclear Power Plants, Nuclear Reactors and Fuels, Advantages and Disadvantages.

Biomass Energy: Principle, Construction of Biogas Plants, Application.

Books Recommended:



1. B.K. Sharma, Industrial Chemistry, 49th Edition, Goel Publishing, 2013.
2. J. Richards, Fossil Fuels, 1st Edition, Marshall Cavendish Benchmark, 2009.
3. A. Solway, Hydrogen Fuel (Energy for the Future and Global Warming), Illustrated Edition, Gareth Stevens Publishing, 2007.
4. D.L. Klass, Biomass for Renewable Energy, Fuels, and Chemicals, 1st Edition, Academic Press, 1998.
5. R.Luque and J. Melero, Advances in Biodiesel Production: Processes and Technologies, 1st Edition, Woodhead Publishing, 2012.

Course Outcomes:

CO1: Develop knowledge about solid and liquid fuel and their operations.

CO2: Analyze various gaseous fuels and evaluate the energy from combustion process.

CO3: Identify renewable energy sources for converting them to energy.

CO4: Apply fuel cell to address the energy issues.

CO5: Identify various forms of energy and their conversion to energy for use.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	3	3
CO2	3	2	3	2	3	3
CO3	3	2	3	2	3	3
CO4	3	2	3	2	3	3
CO5	3	2	3	2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix Row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	2	3	3