Course of Studies

for

Five-Year Integrated Master of Science (Int. M.Sc.)

in

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

www.vssut.ac.in

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 achieve successful professional careers in Chemical industries, Government sectors, Academia and National/International research institutes as innovative scientists.

PEO 02: To provide formal training to students to pick up/practice research skills and work with independent research groups for acquiring higher studies including M.Tech., PhD.

PEO03: To train students to undertake quality control aspects, resolve the problems of chemical process industries and develop leadership skill, social awareness and responsibility, contemporary and also 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 learn basic and advanced concepts of 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 and their application in day to day life.

PSO 02: To synthesize, purify and characterize compounds using established protocols, with the help of standard and modern instrumentation techniques and learn to explore online search tools for literature survey through their project and prepare project report.

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

Five-Year Integrated Master of Science (Int. M.Sc.) in Chemistry

(Session 2019–2020 Onward)

01st SEMESTER

Code	Name of the Subject	L-T-P	Credits
IPH01001	Physics-I	3-1-0	4
ICH01001	Chemistry-I	3-1-0	4
IMA01001	Mathematics-I	3-1-0	4
ICH01002	Environmental Science	3-0-0	2
IPH01002	Physics Lab-I	0-0-3	2
ICH01003	Chemistry Lab-I	0-0-3	2
	Audit-I	0-2-0	0
		Total Credit	18

02nd SEMESTER

Code	Name of the Subject	L-T-P	Credits
IPH02001	Physics-II	3-1-0	4
ICH02001	Chemistry-II	3-1-0	4
IMA02001	Mathematics-II	3-1-0	4
IHU02001	English for Communication	3-0-0	2
IPH02002	Physics Lab-II	0-0-3	2
ICH02002	Chemistry Lab-II	0-0-3	2
	Audit-II	0-2-0	0
		Total Credit	18

03rd SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH03001	Core 01	Physical Chemistry-I	3-1-0	4
ICH03002	Core 02	Organic Chemistry-I	3-1-0	4
ICH03003	Core 03	Inorganic Chemistry-I	3-1-0	4
ICH03004	Core 04	Fundamental of Materials Science	3-1-0	4
ICH03005	Core Lab 01	Organic Lab-I	0-0-3	2
ICH03006	Core Lab 02	Basic Physical Lab	0-0-3	2
			Total Credit	20

04th SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH04001	Core 05	Organic Chemistry-II	3-1-0	4
ICH04002	Core 06	Physical Chemistry-II	3-1-0	4
ICH04003	Core 07	Inorganic Chemistry-II	3-1-0	4
ICH04004	Core 08	Green Chemistry	3-1-0	4
ICH04005	Core Lab 03	Inorganic Lab-I	0-0-3	2
ICH04006	Core Lab 04	Organic Lab-II	0-0-3	2
			Total Credit	20

05th SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH05001	Core 09	Analytical Instrumentation Methods	3-1-0	4
ICH05002	Core 10	Bioinorganic Chemistry	3-1-0	4
ICH05003	Elective-I	Solid Sate Chemistry	3-1-0	4
ICH05004	Elective-II	Polymer Chemistry	3-1-0	4
ICH05005	Core Lab 05	Polymer Chemistry Lab	0-0-3	2
ICH05006	Core Lab 06	Inorganic Lab-II	0-0-3	2
			Total Credit	20

06th SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH06001	Core 11	Natural Products	3-1-0	4
ICH06002	Core 12	Advanced Environmental Chemistry	3-1-0	4
ICH06003	Elective-III	Principles of Inorganic Chemistry	3-1-0	4
ICH06004		Seminar	0-0-0	2
ICH06005	Core Lab 07	Advanced Physical Lab	0-0-3	2
			Total Credit	16

07th SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH07001	Core 13	Structure and Reactivity	3-1-0	4
ICH07002	Core 14	Group theory and Quantum Chemistry	3-1-0	4
ICH07003	Core 15	Thermodynamics and Chemical Dynamics	3-1-0	4
ICH07004	Core 16	Coordination Chemistry	3-1-0	4
ICH07005	Core Lab 08	Inorganic General Lab	0-0-3	2
ICH07006	Core Lab 09	Organic General Lab	0-0-3	2

	Audit-I	0-2-0	0
		Total Credit	20

08TH SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH08001	Core 17	Stereochemistry	3-1-0	4
ICH08002	Core 18	Organic Reaction Mechanism	3-1-0	4
ICH08003	Core 19	Organometallics	3-1-0	4
ICH08004	Core 20	Molecular Spectroscopy	3-1-0	4
ICH08005	Core Lab 10	Physical General Lab	0-0-3	2
ICH08006	Core Lab 11	Environmental and Analytical Lab	0-0-3	2
	Audit-II		0-2-0	0
			Total Credit	20

09th SEMESTER

Code		Name of the Subject	L-T-P	Credits
ICH09001	Core 21	Photochemistry and Pericyclic	3-0-0	3
ICH09002	Core 22	Applications of Spectroscopic Techniques	3-0-0	3
	Elective 1	List of Electives	3-1-0	4
	Elective 2	List of Electives	3-1-0	4
	Open Elective		3-1-0	4
ICH09003	Core Lab 12	Industrial Lab	0-0-3	2
			Total Credit	20

10th SEMESTER

Code		Name of the Subject	L-T-P	Credits
	Elective Paper III	List of Electives	3-1-0	4
	Elective Paper IV	List of Electives	3-1-0	4
ICH10001	Project Dissertation		0-0-4	6
ICH10002	Industrial Training/Internship		0-0-3	0
ICH10003	Comprehensive Viva-voce		0-0-2	2
			Total Credit	16

Grand Total Credit: 18+ 18 +20 +20 +20 + 16 + 20 + 20 + 20 + 16 = 188

List of Electives:

1. Disconnection Approach in Organic Synthesis = ICH09004
2. Supramolecular and Macromolecules = ICH09005
3. Chemical Kinetics and Physical Photochemistry = ICH09006

4. Environmental Chemistry and Management = ICH09007
5. Analytical Chemistry = ICH09008
6. Industrial Process = ICH09009
7. Reactions and Reagents in Organic Synthesis = ICH10004
8. Bioorganic Chemistry = ICH10005
9. Ring Synthesis = ICH10006
10. Chemistry of Materials = ICH10007
11. Materials and Energy Balance = ICH10008
12. Colloids and Surface Chemistry = ICH10009
13. Computational Chemistry = ICH10010

Open Electives:

1. Applied Nanoscience and Nanotechnology = ICHOE901
2. Environmental Assessment and Management = ICHOE902
3. Materials Science = ICHOE903
4. Fuel and Energy = ICHOE904
5. Science of Composite Materials = ICHOE905

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

Five-Year Integrated Master of Science (Int. M.Sc.) in Chemistry

(Session 2019–2020 Onward)

01st SEMESTER

Code:ICH01001 **Subject: Chemistry-I** **Credits: 4[3-1-0]**

Module-I (08 Hours)

Wave Mechanics: de Broglie Equation, Heisenberg's Uncertainty Principle and Its Significance, Schrodinger's Wave Equation, Significance of Ψ and Ψ^2, Quantum Numbers and their Significance, Normalized and Orthogonal Wave Functions. Sign of Wave Functions, Radial and Angular Wave Functions for Hydrogen Atom, Radial and Angular Distribution Curves, Shapes of s, p, d, and f Orbitals, Pauli's Exclusion Principle, Hund's Rule of Maximum Multiplicity, Aufbau's Principle and Its Limitations.

Module-II (08 Hours)

Periodicity of Elements:s, p, d, f Block Elements, the Long Form of Periodic Table, Detailed Discussion of the following Properties of the Elements with reference to s and p-block: (a) Effective Nuclear Charge, Shielding or Screening Effect, Slater Rules, Variation of Effective Nuclear Charge in Periodic Table, (b) Atomic Radii (Van der Waals), (c) Ionic and Crystal Radii, (d) Covalent Radii (Octahedral and Tetrahedral), (e) Ionization Enthalpy, Successive Ionization Enthalpies and Factors Affecting Ionization Energy, Applications of Ionization Enthalpy, (f) Electron Gain Enthalpy, Trends of Electron Gain Enthalpy, and (g) Electronegativity, Pauling's/Mulliken's/Allred Rachow's/ and Mulliken-Jaffé's Electronegativity Scales, Variation of Electronegativity with Bond Order.

Module-III (08 Hours)

Kinetic Theory of Gases: The Properties of Gases, Kinetic Model of Gases, Real Gases, Maxwell-Boltzmann Distribution Molecular Velocities (Mathematical Derivation excluded), Calculation of Root Mean Square Velocity (R.M.S), Most Probable and Average Velocities and their Relation Between Them, Mean Free Path Collision Frequency, Deviation of Gas Laws form Ideal Behaviour, Vander Waals Equation of State, Critical Phenomena and Critical Constants, Law of Corresponding States and Reduced Equation of State.

Module-IV (08 Hours)

Liquid State:(i) Qualitative Treatment of the Structure of the Liquid State; Physical Properties of Liquids; Vapour Pressure, Surface Tension and Coefficient of Viscosity, and their Determination, Effect of Addition of Various Solutes on Surface Tension and Viscosity.

Explanation of Cleansing Action of Detergents, Temperature Variation of Viscosity of Liquids and Comparison with that of Gases.

Module-V (08 Hours)

Solid State: Nature of the Solid State, law of Constancy of Interfacial Angles, Law of Rational Indices, Miller Indices, Elementary Ideas of Symmetry, Symmetry Elements and Symmetry Operations, Seven Crystal Systems and Fourteen Bravais Lattices; X-ray Diffraction, Braggs Law, A Simple Account of Rotating Crystal Method and Powder Pattern Method, Analysis of Powder Diffraction Patterns of NaCl, CsCl, and KCl, Defects in Crystals.

Books Recommended:

1. J.D. Lee, Concise Inorganic Chemistry, 5th Edition, Oxford University Press, 2008.
2. P.W. Atkins and J. de Paula, Elements of Physical Chemistry, 4th Edition, Oxford University Press, 2005.
3. J.E. Huheey, E.A. Keiter and R.L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, Pearson, 1997.
4. B.R. Puri, L.R. Sharma, and K.C. Kalia, Principles of Inorganic Chemistry, VishalPublishing, 33rd Edition, 2020.
5. S. Prakash, G.D. Tuli, S.K. Basu, and R.D. Madan, Advanced Inorganic Chemistry - Volume I and II, 19th Edition, by S.Chand Publication, 1944.
6. B.R. Puri, L.R. Sharma, M.S. Pathania, Principles of physical Chemistry, Vishal Publishing, 47th Edition, 2017.

Course Outcomes:

CO1: Evaluate the behavior and interactions between, matter and energy at the atomic and molecular levels.

CO2: Analyze the periodic table and periodicity of properties.

CO3: Express the behavior of gas.

CO4: Demonstrate the behavior of liquid state of matter.

CO5: Evaluate the structure of solid state of matter.

Course Articulation Matrix

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

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

Code:ICH01002 **Subject: Environmental Science** **Credits: 4[3-1-0]**

Module-I (08 Hours)

Concept of Environment: Scope of Ecology, Component of Ecosystem, Classification of Ecosystem, Ecological Factors (Climate, Edaphic, Topographical, and Biotic Factor), Bio-geochemical Cycle (Oxygen Cycle, Carbon Cycle, and Nitrogen Cycle), Aquatic and Terrestrial Ecosystems.

Module-II(08 Hours)

Concept of Atmosphere: Sources of Air Pollution (Man-made and Natural), Major and Minor Pollutants in Atmosphere, Chemical and Photo-chemical Reaction in Atmosphere, Photo- chemical Smog, Acid Rain, Green House Effect and Global Warming, Ozone Layer Depletion, History of Major Pollution Episodes.

Module-III(08 Hours)

Concept of Hydrosphere: Sources and Causes of Water Pollution, Types of Water Pollution, Ground Water Pollution, Oil Pollution, Eutrophication, Radio-active and Thermal Pollution, Various Health Problem due to Water Pollution.

Module-IV(08 Hours)

Soil Pollution: Concept of Lithosphere, Composition of Soil Structure, Micro and Macro Nutrient in Soil, Types of Soil Pollution, Sources of Soil Pollution, Effects of Pesticides and Fertilizers in Soil, Formation of Soil, Conservation of Soil.

Module-V (08 Hours)

Pollution due to Noise: What is Noise? Sources of Noise Pollution, Permissible Level in Decibel Scale, Effect of Noise on Human Health, Prevention and Control of Noise Pollution.

BooksRecommended:

1. S.E. Manahan, Environmental Chemistry, 9thEdition, CRC Press, 2009.
2. A.K. De, Environmental Chemistry, 2ndEdition, New Age International, 2006.
3. B.K. Sharma and H. Kaur, An Introduction to Environmental Pollution, Goel Publishing.

4. S.M. Khopkar, Environmental Pollution Analysis, 2nd Edition, New Age International, 2010.
5. C. Baird and M. Cann, Environmental chemistry, 5th Edition, W.H. Freeman, 2012.
6. M.C. Dash, Ecology,Chemistry and Management of Environmental Pollution, 1st Edition, MAC Millan, 2004.
7. N.A.Siddiqui and Akbar Ziauddin, Natural Resources and Environmental Management Systems, 1st Edition, Khana Publishers, 2008.
8. S. Panda, Environment andEcology, 1st Edition, Vrinda Publications, 2005.

Course Outcomes:

CO1: Master core concepts and methods from ecological and physical sciences and their application in environmental problem solving. Master core concepts and methods from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.

CO2: Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems. Understand the transnational character of environmental problems and ways of addressing them, including interactions across local to global scales.

CO3: Apply systems concepts and methodologies to analyze and understand interactions between social and environmental processes.

CO4: Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.Environmental management in industries and regulating offices.

CO5: Demonstrate proficiency in quantitative methods, qualitative analysis, critical thinking, and written and oral communication needed to conduct high-level work as interdisciplinary scholars and/or practitioners. To introduce the students about the environments, nature and different types of pollution, which effect directly or indirectly the existence of life on this planet. Students will aware about their environment and also will get related service in

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	3	3	3	3

CO4	3	3	3	3	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	3	3	3	3

Code: ICH01003 Subject: Chemistry Lab-1 Credits: 2[0-0-3]

1. Determination of Hardness of Water.
2. Determination of Percentage Purity of Lime Stone Sample.
3. Determination of Dissolved Oxygen in Water.
4. Determination of Sodium Carbonate and Sodium Bicarbonate Content in a Mixture.
5. Determination of Sodium Carbonate and Sodium HydroxideContent in a Mixture.
6. Determination of Iron Content in a Sample.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1: Evaluate and analyze the hardness of water samples.

CO2: Express the percentage of Purity of Lime Stone Sample.

CO3: Define and demonstrate the dissolved Oxygen in Water.

CO4: Compile the Sodium Carbonate and Sodium Bicarbonate Content in a Mixture.

CO5: Analyze and evaluate the Iron Content in a Sample.

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	3	3	3	3
CO4	3	3	3	3	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	3	3	3	3

02nd SEMESTER

Code:ICH02001 **Subject: Chemistry-II** **Credits: 4[3-1-0]**

Module-I (08 Hours)

Chemical Energetics: Review of thermodynamics and the Laws of Thermodynamics, Important Principles and Definitions of Thermochemistry, Concept of Standard State and Standard Enthalpies of Formations, Integral and Differential Enthalpies of Solution and Dilution, Calculation of Bond Energy, Bond Dissociation Energy and Resonance Energy from Thermochemical Data. Variation of Enthalpy of a Reaction with Temperature, Kirchhoff's Equation. Statement of Third Law of Thermodynamics.

Module-II (08 Hours)

Chemical Equilibrium: Free Energy Change in a Chemical Reaction. Thermodynamic Derivation of the Law of Chemical Equilibrium. Distinction Between ΔG and ΔG_o, Le Chatelier's Principle. Relationships between K_p, K_c, and K_x for Reactions involving Ideal **Gases.**

Module-III (08 Hours)

Ionic Equilibria: Strong, Moderate and Weak Electrolytes, Degree of Ionization, Factors Affecting Degree of Ionization, Ionization Constant and Ionic Product of Water. Ionization of Weak Acids and Bases,p^HScale, Common Ion Effect. Salt Hydrolysis, Calculation of Hydrolysis Constant, Degree of Hydrolysis and p^H for Different Salts. Buffer Solutions, Solubility and Solubility Product of Sparingly Soluble Salts, Applications of Solubility Product Principle.

Module-IV (08 Hours)

Structural Theory in Organic Chemistry: Types of Bond Fission and Organic Reagents (Electrophilic, Nucleophilic, and Free Radical Reagents including Neutral Molecules like H_2O,NH_3, and $AlCl_3$).

Bond Polarization: Factors Influencing the Polarization of Covalent Bonds, Electronegativity, Inductive Effect. Application of Inductive Effect (a) Basicity of Amines (b) Acidity of Carboxylic Acids, and (c) Stability of Carbonium Ions, Resonance or Mesomeric Effect, Application to (a) Acidity of Phenol, and (b) Acidity of Carboxylic Acids,Hyperconjugation and Its Application to Stability of Carbonium Ions, Free Radicals and Alkenes, Carbanions and Carbenes.

Types of Organic reactions: Addition - Electrophilic, Nucleophilic and Free Radical. Substitution - Electrophilic, Nucleophilic and Free Radical. Elimination- Examples.

Module-V (08 Hours)

Stereochemistry: Fischer Projection, Newmann and Sawhorse Projection Formulae and their Interconversions.

Geometrical Isomerism: cis–trans and, syn-anti Isomerism E/Z Notations with C.I.P.Rules.**Optical Isomerism:** Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers,Molecules with Two or more Chiral-centres, Distereoisomers, Meso Structures, Racemic Mixture and Resolution. Relative and Absolute Configuration: D/L and R/S Designations.

Books Recommended:

1. P. W. Atkins, Elements of Physical Chemistry, 4th Edition, Oxford University Press, 2007.
2. R.T. Morrison, R.N. Boyd, and S.K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Education, 2010.
3. E.L. Eliel and S.H. Wilen, Stereochemistry of Organic Compounds, 1st Edition, Wiley-Interscience, 1994.
4. B.R. Puri, L.R. Sharma, and M.S. Pathania, Principles of Physical Chemistry, 47th Edition, Vishal Publishing, 2017.
5. P.S. Kalsi, Stereochemistry Conformation and Mechanism, 8th Edition, New Age International, 2015.
6. I.L. Finar, Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002.

Course Outcomes

CO1: Define and demonstrate the thermodynamics and energetics of a chemical reaction.

CO2: Analyze the concept of chemical equilibrium and apply it in different chemical process applications.

CO3: Apply the concepts of ionic equilibria to different applications.

CO4: Express to identify the types of organic reagent and reactions.

CO5: Reorganize the basic concept of stereochemistry for different molecules.

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

Code:ICH02002 Subject: Chemistry Lab-1I Credits: 2[0-0-3]

Qualitative Analysis of Mixtures of Inorganic Substances Containing not More than Four Radicals (Interfering Acid Radicals LikeCO_3^{2-}, SO_3^{2-}, SO_4^{2-},S^-, NO_2^-,NO_3^-,Cl^-, Br^-,I^-, PO_4^{3-}, andAsO_3^{3-})

Books Recommended:

1. G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edition, Longman, 1996.
2. A.K. De and A.K. De, Inorganic Chemistry and Analysis, 2nd Edition, New Age International, 2005.

Course Outcomes:

CO1: Demonstrate proficiency in quantitative and qualitative methods for analyzing the mixtures of Inorganic Substances.

CO2: Analyze the unknown samples.

CO3: Evaluate and write the basic principles involved to organize the unknown mixture samples.

CO4: Compile the radicals on the basic of group tests.

CO5: Analyze and evaluate basic and acid radicals.

Course Articulation Matrix

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

03rd SEMESTER

Core 01 Code: ICH03001 Subject: Physical Chemistry-I Credits: 4[3-1-0]

Module-I (08 Hours)

Dilute Solutions: Vapour Pressure, Raoults Law, and Thermodynamic Derivation of Laws Relating to Elevation of Boiling Point, Depression of freezing Point, and Osmotic Pressure. Ideal and Non-ideal Solution Association and Dissociation.

Module-II (08 Hours)

Homogenous Equilibrium: Law of Mass Action and the Thermodynamic Derivation of the Expression for Equilibrium Constant, Different Forms of Equilibrium Constants. Le Chatelier's Principle, Illustrations with Some Gaseous Reactions. Effect of Temperature on Equilibrium, Van't-Hoff's Equation and Its Integration.

Module-III (08 Hours)

Chemical Kinetics: Order and Molecularity, Kinetics of Ist and IInd Order Reactions, Complex Reactions, Reversible Reaction, Consecutive Reaction, parallel Reaction, Effect of Temperature on Reaction Rate, Collision Theory of Reaction Rate, Qualitative Treatment of Transition Theory.

Module-IV (08 Hours)

Thermodynamic Concept: Internal Energy, Heat Content, Heat Capacity at Constant Volume and Constant Pressure, Relation betweenC_v and C_p, Work Done for Ideal Gases in Isothermal and Adiabatic Change.

Thermochemistry: Heat Changes in Chemical Reactions, Hess's Law, Kirchoff's Equation, Carnot's Theorem and Carnot's Cycle, Efficiency of Heat Engine.

Module-V (08 Hours)

Spontaneous Process, Entropy Changes in Reversible and Irreversible Processes, Entropy of Mixture of Ideal Gases, Free Energy and Work Function Condition for Equilibrium, Gibb's-Helmholtz Equation, Clausius-Clapeyron Equation.

Books Recommended:

1. P.W. Atkins and J. de Paula, Elements of Physical Chemistry, 6th Edition, Oxofrd University Press, 2012.
2. G.M. Barrow, Physical Chemistry, 6th Revised Edition, McGraw-Hill, 1996.

3. K.L. Kapoor, A Text Book of Physical Chemistry, Volume I–IV, 3rd Edition, Macmillan Publishers,2006.

Course Outcomes:

CO1: Define and express various properties of dilute solutions like boiling point, freezing point, osmotic pressure, vapour pressure and laws, processes involved in that.

CO2: Demonstrate the chemical equilibrium processes involved in a chemical reaction.

CO3: Evaluate and analyze the kinetics of various simple and complex reactions.

CO4: Analyze and development on thermodynamic concept and thermochemistry associated with a system.

CO5: Evaluate and apply basic principle on chemical thermodynamics of close system and phase equilibria.

Course Articulation Matrix

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

Core 02 Code: ICH03002 Subject: Organic Chemistry-I Credits: 4[3-1-0]

Module-I(10 Hours)

Reaction Intermediates: Formation, Stability and Structure of Free Radicals and Carbenes, Nitrene, Enamine, and Benzyne, Reaction in Organic Compounds, Classification of Reactions: Substitution, Addition, Elimination, Electron Transfer Reaction, Molecularity, Order of Reactions, Transition State and Intermediates, Nucleophiles and Electrophiles.

Module-II(05 Hours)

Configurational Isomerism: Optical Isomerism: Introduction, Conditions for Optical Activity, Optical Rotation, Specific Rotation, D and L Convention, R and S Notations,

Optical Isomers of Lactic, and Tartaric Acids, Enantiomers and Diastereomers, Threo and Erythro Nomenclature, Meso Compounds, Racimic Modification, Methods of Resolution.

Module-III(05 Hours)

Geometrical Isomerism: Introduction, Structural Requirement (Cis and Trans, Syn and Anti), E- Z Convention, Configuration of Oximes.

Conformational Isomerism: Introduction, Conformations of Ethane and n-Butanes and Cyclohexane, Baeyer Strain Theory.

Module-IV(10 Hours)

Grignard's Reagent: Preparation, Structure, Synthetic Uses.

Esters Containing Active Methylene Groups: Acetoacetic Ester: Synthesis, Synthetic Uses, structure and Keto-Enol Tautomerism

Malonic Ester: Preparation and Synthesis Uses.

Carbohydrates: Classification, Configuration of Sugars, Glucose and Fructose (Occurrence, Reaction: Osazone formation with Felhing's Solution, Mutarotaion, Elucidation of Structure of D-Glucose (Open Chain and Ring Structure).

Module-V(10 Hours)

Heterocyclic Compounds: Five Membered Heterocyclics: Pyrrole, Thiophene and Furan: Synthesis (from Sugar, Dicarbonyl Compound), Properties (Aromaticity, Electrophillic Substitution Reactions)

Acyclic Compounds: Preparation, Reactions and Stability.

Aryl Nitrogen Compounds: Nitro Hydrocarbons, Preparations, Properties, Reduction of Nitro Benzene, TNT, Amines.

Books Recommended:

1. P.Y. Bruice, Organic Chemistry, 7th Edition, Pearson Education, 2013.
2. R.K. Bansal, A Textbook Organic Chemistry, 5th Edition, New Age International, 2007.
3. J. Clayden, N. Greeves, and S. Warren, Organic Chemistry, 2nd Edition, Oxford University Press, 2012.
4. T.W.G. Solomons, C.B. Fryhle, and S.A. Snyder, Organic Chemistry, 11th Edition, John Wiley and Sons, 2013.
5. L.G. Wade Jr., Organic Chemistry, 8th Edition, Prentice Hall, 2012.
6. S.K. Ghosh, Advanced General Organic Chemistry: A Modern Approach: Volume I and II, 3rd Edition, New Central Book, 2010.
7. J.E. McMurry, Organic Chemistry, 8th Edition, Brooks/Cole, 2012.
8. T.N. Sorrell, Organic Chemistry, 2nd Edition, University Science Books, 2006.

9. D.R. Klein, Organic Chemistry, 2nd Edition, John Wiley and Sons, 2013.
10. J.M. Hornback, Organic Chemistry, 2nd Edition, Thomson Brooks/Cole, 2006.

Course Outcomes:

CO1: Define the formation, stability and structure of different reaction intermediate and able to identify the type of reaction and mechanism.

CO2: Get the basic concepts of optical isomerism and related concepts.

CO3: Make out the basic concepts of geometric isomerism and conformational isomerism.

CO4: Able to synthesise different organic compounds from Grignard's Reagent and Esters Containing Active Methylene Groups and inculcate the basic chemistry of sugars.

CO5: Apprise the preparation and reactions of Aryl Nitrogen Compounds, Nitro Hydrocarbons, Acyclic Compounds, and Five Membered heterocyclic compounds.

Course Articulation Matrix

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

Core 03 Code: ICH03003 Subject: Inorganic Chemistry-I Credits: 4[3-1-0]

Module-I (08 Hours)

Chemical Bonding-I

Ionic Bond: General Characteristics, Types of Ions, Size Effects, Radius Ratio Rule and Its Limitations. Packing of Ions in Crystals. Born-Landé Equation with Derivation and Importance of Kapustinskii Expression for Lattice Energy, Madelung Constant, Born-Haber Cycle and Its Application, Solvation Energy.

Covalent Bond: Lewis Structure, Valence Bond Theory (Heitler-London Approach). Energetics of Hybridization, Equivalent and Non-equivalent Hybrid Orbitals. Bent's Rule,Resonance and Resonance Energy, Molecular Orbital Theory, Molecular Orbital

Diagrams of Diatomic and Simple Polyatomic Molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their Ions, HCl, BeF_2, CO_2 (Idea of s-p Mixing and Orbital interaction to be given), Formal Charge, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of Simple Molecules and Ions containing Lone Pairs and Bond Pairs of Electrons, Multiple Bonding (σ and πBond Approach) and Bond Lengths.

Module-II (08 Hours)

Chemical Bonding-II

Covalent Character in Ionic Compounds, Polarizing Power and Polarizability. Fajan's Rules and Consequences of Polarization. Ionic Character in Covalent Compounds: Bond Moment and Dipole Moment. Percentage Ionic Character from Dipole Moment and Electronegativity Difference.

Qualitative Treatment of MOT, Bonding, Antibonding and Nonbonding Molecular Orbitals, MO Configuration of H_2, N_2, O_2, CO, NO, HX and their Ions.

Metallic Bond: Qualitative Idea of Valence Bond and Band Theories. Semiconductors and Insulators, Defects in Solids.

Module-III (08 Hours)

Compounds of p-Block Elements: Preparation and Structure

a. Boron Family: Boric acid, Hydrides of Boron and Borazole.
b. Carbon Family: Carbides, Silanes, Silicates and Silicones.
c. Nitrogen Family: Hydrides of Nitrogen.
d. Oxygen family: Oxygen fluorides, Peracids of Sulphur.
e. Halogen family: Oxides and Oxyacids of Chlorides, Inner Halogen Compounds.

Module-IV (08 Hours)

Chemistry of d-Block Elements: Electronic Configuration and Comparative Study of I^{st}, II^{nd}, and III^{rd}Row Transition Elements with Special Reference toAtomic and Ionic Radii, Ionization Potential, Redox Potential, Oxidation State, and Catalytic Activity, Principle of Extraction of Chromium and Manganese.

Module-V (08 Hours)

Coordination Compounds: Ligands, Coordination Number, Coordination Sphere, Nomenclature, Werner'sCoordination Theory, Effective Atomic Number (EAN) Chelates, Isomerism in Coordination Compounds, Valence Bond Theory of Transition Metal Complexes with Special Reference to Octahedral and Tetrahedral and Square Planar Complexes.

Books Recommended:

1. J.D. Lee, Concise Inorganic Chemistry, 5th Edition, John Wiley and Sons, 2008.
2. J.E. Huheey, E.A. Keiter, and R.L. Keiter, Inorganic chemistry: Principle, Structure and Reactivity. 4thEdition, Pearson, 1997.
3. B.R. Puri, L.R. Sharma, and K.C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing, 33rd Edition, 2020.
4. S. Prakash, G.D. Tuli, S.K. Basu, and R.D. Madan, Advanced Inorganic Chemistry - Volume I and II, 19th Edition, by S. Chand Publication, 1944.

Course Outcomes:

CO1: Define and analyze the theories of ionic bonding and covalent bonding.

CO2: Apply the basic principle on the covalent bonding of ionic compounds, the basics of molecular orbital theory of and metallic bonding.

CO3: Evaluate and demonstrate the structure and reactivity of p block elements.

CO4: Analyze and express the properties and principle of extraction of d block elements.

CO5: Demonstrate and develop the basic idea on the nomenclature and bonding of coordination compounds.

Course Articulation Matrix

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

Core 04 Code:ICH03004 Subject: Fundamentals of Material Chemistry Credits: 4[3-1-0]

Module-I (08 Hours)

Classification of Materials, Structure-Property Relationship

Metals and Alloys: Metals and their Properties, Physical Properties, Electrical Conductivity, Thermal Conductivity and Magnetic Properties, Alloying Nature, Alloys, Alloys of Aluminium, Magnesium, Titanium, Copper, Nickel, Lead, Zinc and Tin for Application.

Module-II (08 Hours)

Polymers: Definition, Types of Polymers, General Properties of Polymer,

Industrial Polymers: Properties and Applications of Industrial Polymers; PP, PE,PVC, PS, polyamide, Polyacrylates, and Polyester (PET, PBT).

Polymer Degradation: Types of Degradation, Thermal, Mechanical, Ultrasonic and Photodegradation, Oxidative and Hydrolytic Degradation, Biodegradable Polymers

Module-III(08 Hours)

Ceramic Materials: Types, Structure (Silicate, Perovskite, Rock Salt Like, Fluorite Structure), Properties, Applications.

Composite Materials: Definition, Composition, Classification, Properties of Composites, Reinforced Concrete, Glass Fibre Reinforced Plastics, Carbon Fibre Reinforced Plastics, Reinforced Plastics, Laminated Sheets, Hybrid Composites.

Module-IV(08 Hours)

Nanomaterials: Introduction to Nanomaterials, Types, General Properties, Applications of Nanomaterials in Medicine, Fuel Cell, Catalysis,and Environmental Engineering, Carbon Nanotubes (Synthesis, Properties and Applications).

Module-V (8 Hours)

Electronic Materials: Chemistry of Semiconductors, Classification (Intrinsic and Extrinsic Material (*n* Type and *p* Type)), Properties, and Applications.

BooksRecommended:

1. W.D.Callister, Materials Science and Engineering: An Introduction, 8th Edition, John Wiley and Sons, 2010.
2. L.H.Van Vlack, Elements of Material Science and Engineering, 6th Edition, Addison-Wesley, 1989.
3. D.R. Askeland, P.P Phule, and W.J. Wright, The Science and Engineering of Materials, 6th Edition, Wadsworth Publishing, 2010.
4. V. Raghavan, Materials Science and Engineering: A First Course, 5th Edition, Prentice Hall, 2004.
5. D.R. Askeland and P.P.Phule, Essentials of Material Science and Engineering, 2nd Edition, Cengage, 2013.
6. D. Yesudian, Materials Sciences and Metallurgy, Scitech Publications, 2015.
7. C.K.Dutta, Material Science and Metallurgy, Dhanpat Rai.
8. R.B. Choudhary, Materials Science and Metallurgy, Khanna Publishers, 1987.

9. L.K. Reddy, Principles of Engineering Metallurgy, 2nd Edition, New Age International, 2008.
10. S.K.H. Chowdhury, Material Science and Processes, Indian Book distributing.
11. K.G. Budinski and M.K. Budinski, Engineering Materials: Properties and Selection, 9th Edition, Pearson, 2009.
12. M.S. Vijaya and G. Rangarajan, Materials Science, McGraw Hill, 2004.

Course Outcomes:

CO1: Able to distinguish about the different types of materials and their properties and specifically gain information about metals and alloys.

CO2: Define the basic properties and applications of polymers.

CO3: Evaluate the properties, structure and applications of ceramic and composite materials.

CO4: Gain basic idea about the nanomaterials and their applications.

CO5: Able to identify the different smart materials and understand the chemistry of electronic materials.

Course Articulation Matrix

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

Core Lab 01 Code: ICH03005 Subject: Organic Lab-I Credits: 2[0-0-3]

1. Detection of Functional Groups: Element Detection, Detection of Amine, Alcohol, Nitro, Acid, Amide, etc.
2. Purification of Organic Solvents using Distillation.
3. Chromatography.
4. Drying of Organic Solvents.
5. Preparation of Benzoic Acid from Ethyl Benzoate.
6. Preparation of p-bromoacetanilide from Acetanilide.
7. Extractions of Caffeine from Tea Leaf.
8. Extractions of Casein from Milk.
9. Isolation of piperine from Black Pepper.

Books Recommended:

1. V.K. Ahluwalia and R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, 1st Edition, University Press, 2000.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, and A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, ELBS Longman, 1996.
3. P.R. Singh, D.S. Gupta, K.S. Bajpai, Experimental Organic Chemistry, Volume 2, Qualitative and Quantitative Analysis,Tata McGraw-Hill, 2004.
4. A. Ault, Techniques and Experiments for Organic Chemistry, 6th Edition,University Science Book, 1998.

Course Outcomes:

CO1: Analyze Functional Groups present in organic compounds.

CO2: To develop skills in the field of Isolation processes.

CO3: To prepare dry solvents which are required for organometallic reactions.

CO4: Synthesize new organic compounds.

CO5: Characterize organic compounds.

Course Articulation Matrix

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

Core Lab 02 Code: ICH03006 Subject: Basic Physical Lab Credits: 2[0-0-3]

1. Study of the Distribution Equilibrium of Iodine in Water/Tolune.
2. Determination of Hydrolysis Rate of Ester.
3. Determination of Molecular Mass by Victor Mayer Apparatus.
4. Estimation of Ca and Mg in Mixture by EDTA.
5. Determination of Eutectic Point of a Binary Mixture.

6. Estimation of Ni by DMG Complex by Spectrometry.
7. Ionization Constant of a Week Acid.
8. Solubility of a Sparingly Soluble Salt.

Books Recommended:

1. R.C. Das and B. Behera, Experimental Physical Chemistry, Tata McGraw-Hill, 1983.
2. D. Alart, Practical Physical Chemistry, Longman, 1993.
3. C.W. Garland, J.W. Nibler, and D.P. Shoemaker, Experiments in Physical Chemistry, 4th Edition, McGraw-Hill, 2009.
4. P S Sindhu, Practicals in Physical Chemistry A Modern Approach, 1st Edition, 2006.
5. B. Viswanathan, P.S. Raghavan,Practical Physical Chemistry, Viva Books, 2015.
6. S.K. Maity and N.K. Ghosh, Physical Chemistry Practical, 1st Edition, New Central Book, 2012.

Course Outcomes:

CO1: Demonstrate and Evaluate the Distribution Equilibrium of Iodine in Water/Tolune.

CO2: Evaluate and Analyze the Hydrolysis of Rate of Ester.

CO3: Evaluate and Demonstrate the Ca and Mg in Mixture by EDTA.

CO4: Express the Percentage of Ni by DMG Complex by Spectrometry.

CO5: Analyze and Evaluate Ionization Constant of a Weak Acid.

Course Articulation Matrix

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

04th SEMESTER

Core 05 Code:ICH04001 Subject: Organic Chemistry-II Credits: 4[3-1-0]

Module-I(10 Hours)

Types of Mechanisms, types of Reactions, Aliphatic SubstitutionReaction: SN^1, SN^2 and SN^i Reactions (Kinetics, Stereochemistry, Structural and Environmental Aspects), Neighbouring Group Participation Reactions.

Conformational Isomerism: Introduction Conformations of Cyclohexane, Conformational Analysis, Mono- and Di- substituted Cyclohexanes.

Module-II(06 Hours)

Heterocyclic Compounds:

Six Membered Heterocycles: Pyridine and Quinoline (Preparation and Reactions).

Fused Heterocycles: Urides and Purines, Elucidation of Structure of Uric Acid.

Indigo: Structure and Use.

Module-III(04 Hours)

Polynuclear Hydrocarbons: Naphthalene and Anthracene (Addition and Electrophilic Substitution Reactions, Elucidation of their Structures).

Module-IV(10 Hours)

Alkaloids: Introduction Elucidation of Structure of Nicotine, Papaverine.

Terpenes: Introduction Isoprene Rule, Elucidation of the Structure of the Camphor

Vitamins: Introduction, Elucidation of the Structure of the Vitamine C.

Module-V(10 Hours)

Mechanism and Applications: Pinacol-Pinacolone, Demjanov, Dienone-Phenol, Beckmann and Benzidine, Diels-Alder, Schmidt, Lossen, Curtius Reaction.

Synthesis and Application of Reagent: $LiAlH_4$, $NaBH_4$, HIO_4, IBD, PCC and DCC.

Books Recommended:

1. P.Y. Bruice, Organic Chemistry, 3rdEdition, Pearson Education, 2009.
2. T.W.G. Solomons, C.B. Fryhle, and S.A. Snyder, Organic Chemistry, 11thEdition, John Wiley and Sons, 2014.
3. T.L. Gilchrist, Heterocyclic Chemistry, 3rdEdition, Pearson Education, 2008.
4. S.K. Ghosh, Advanced General Organic Chemistry: A Modern Approach: Volume I and II, 3rdEdition, New Central Book, 2010.

Course Outcomes:

CO1: Evaluate and explain the detail mechanism, stereochemical aspect and effect of different factors on the nucleophilic substitution reaction and ability to accomplish the Conformational Analysis of cyclohexanes.

CO2: Compile and express the preparation, reactions and structure elucidation of different organic compounds such as six membered Heterocyclics, Polynuclear Hydrodcarbons, Fused Heterocycles: Urines and Purines, Indigo etc.

CO3: Compile and demonstrate the structure elucidation and chemical properties of some polynuclear hydrocarbons.

CO4: Planning the isolation, structural elucidation, synthesis and application of some natural products such as Alkaloids, Terpenes, and Vitamins.

CO5: Application of some reagents such as $LiAlH_4$, $NaBH_4$, HIO_4, IBD, PCC and DCC and analysis of the mechanism and application of some name reaction and rearrangements.

Course Articulation Matrix

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

Core 06 Code:ICH04002 Subject: Physical Chemistry-II Credits: 4[3-1-0]

Module-I(08 Hours)

Weak and Strong Electrolytes, Arrhenius Theory, Ostwald's Theory,Debye-Hückel Theory of Strong Electrolytes (Qualitative IDEA only). Measurement for Determination of Solubility and Solubility Product, Degree of Ionization, Ionic Product of Water, Transference Number and Its Determination by Hittorf's Method, and Moving Boundary Method, Conductometric Titration.

Module-II (08 Hours)

Electrochemistry: Galvanic Cell, Cell Reaction, Reversible Electrode, Types of Reversible Electrodes, Nernst Equation and Its Application, Expression of Single Electrode Potential, Reference Electrode (Calomel, Hydrogen, Silver Chlorides).

Module-III (08 Hours)

Redox Potential, Concentration Cell with and without Transference, Liquid Junction Potential, Determination of Mean Ionic Activity Coefficient of Electrolyte. Application of Conductivity measurement, Measurement of Electrolytic Conductance.

Module-IV (08 Hours)

Equilibrium in Electrolyte: Acids and Bases, Theories of Acid and Bases, Determination of p^H by EMF Method (Hydrogen, Quinhydrone, and Glass Electrode).

Buffer Solution, Henderson Equation, Acid Base Indicator and Indicator Constants, Neutralization Curves.

Module-V (08 Hours)

Photochemistry: Beer-Lambert Law, Grotthuss-Draper Law, Stark-Einstein Law of Photochemical Equivalence, Quantum Yield, Comparison between Thermal and Photochemical Reactions, Decomposition of HI, Elementary Idea about Photosensitized Reaction and Photosynthesis (Jablonsky Diagram, Fluorescence and Chemiluminescence, Bioluminescence, Phosphorescence)

Books Recommended:

1. A. Bahl, B.S. Bahl, and G.D. Tuli, Essential of Physical Chemistry, 19thEdition, S. Chand and Sons, 2012.
2. B.R. Puri, L.R. Sharma, and M.S. Pathania, Principles of Physical Chemistry, 47th Edition, Vishal Publishing, 2017.
3. K.L. Kapoor, A Textbook of Physical Chemistry, Volume I–IV, 3rd Edition, Macmillan, 2012.
4. U.N. Dash, O.P. Dharmarha, and P.L. Soni, Textbook Physical Chemistry, 23rdEdition, S. Chand and Sons, 2014

Course Outcomes:

CO1: Apply the different theories to understand the concept of electrolytes and determine the different parameters Solubility and Solubility Product, Degree of Ionization, Ionic Product of Water using conductance measurement.

CO2: Define different types of electrodes, able to design a galvanic cell, ensure its reversibility, and calculate the cell/electrode potential using Nernst's equation.

CO3: Design a concentration cell knowing the concept of liquid junction potential; apply the conductivity measurement for different applications.

CO4: Define the concept of Acids, bases, buffer solution; determine the PH of the solution by EMF methods using different indicator electrodes, able to classify the acid base indicators for titration.

CO5: Apply the laws of photochemistry for different photochemical reactions and differentiate the different photochemical phenomenon using the Jablonsky diagram.

Course Articulation Matrix

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

Core 07 Code:ICH04003 Subject: Inorganic Chemistry-II Credits: 4[3-1-0]

Module-I(08 Hours)

Metal-Ligand Bonding in Metal Complexes: Crystal Field Theory. Qualitative Idea About d-Orbital Splitting in Octahedral and Square Planar Field, Calculation of Crystal Field Stabilization Energy, Explanation of Magnetism, Geometry and Colour of the Coordination Compounds on the Basis of the Valence Bond Theory and Crystal Field Theory, John-Teller Effect in Octahedral Complexes.

Module-II(08 Hours)

Thermodynamic, Kinetic and Magnetic Aspects of Metal Complexes: A Brief Outline of Thermodynamic Stability of Metal Complexes and Factors Affecting the Stability, Substitution Reactions of Square Planar Complexes. Types of Magnetic Behaviour, Spin-Only Formulae, μ_{Eff} and μ_{L+S} Values, Orbital Contribution to Magnetic Moments Application of Magnetic Moment Data for 3d-Metal Complexes.

Module-III(08 Hours)

Chemistry of f-block Elements:

Lanthanides: General Study, Electronic Configurations, Oxidation States, Magnetic, Spectral and Complex Forming Properties, Lanthanides Contraction, Its Causes and Consequences, Separation of Lanthanides by Ion Exchange Methods.

Actinides: Electronic structure, Comparison with Lanthanides, Ionic Radii, Oxidation States and Stereochemistry, Chemistry of Uranium and Thorium.

Module-IV(08 Hours)

Organometallic Chemistry: Definition, Nomenclature and Classification, Preparation, Properties, Bonding and Applications of Alkyls and Aryls of Li, Al, Hg, Sn, and Ti, A Brief Account of Metal Ethylenic Complexes and Homogeneous Hydrogenation, Preparation, Structures and Bonding of Carbonyls of Cr, Mn, Co, and Ni, Effective Atomic Number Rule.

Module-V(08 Hours)

Inorganic Polymers: Types of Inorganic Polymer, Comparison with Organic Polymer, Structure, Aspects and Applications of Silicones, Phosphonitrillic Halides and Condensed Phosphates.

Non-aqueous Solvents: Classification of Solvents and their General Characteristics, Solubility and Reaction in Non-aqueous Solvents (liquid NH_3 and Liquid SO_2).

Books Recommended:

1. J.D. Lee, Concise Inorganic Chemistry, 5th Edition, John Wiley and Sons, 2008.
2. J.E. Huheey, E.A. Keiter, R.L. Keiter, and O.K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition, Pearson Education, 2009.

Course Outcomes:

CO1: Define and demonstrate the theories of bonding in coordination compounds.

CO2: Compile and construct the difference between thermodynamic and kinetic stability, inert and labile complexes and determination of stability constants.

CO3: Define and apply the fundamental idea about the chemistry of f- block elements.

CO4: Demonstrate and organize the fundamentals, nomenclature, basics of synthesis and reactions of organometallic compounds.

CO5: Evaluate the classification, synthesis, reactions of inorganic polymers and introduction to non-aqueous solvents.

Course Articulation Matrix

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

CO5	3	2	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	**3**	**2**	**3**	**2**	**2**	**3**

Core 08 Code:ICH04004 Subject: Green Chemistry Credits: 4[3-1-0]

Module-I(10 Hours)

Green alternatives to Synthesis Organic Transformations: Principles, Planning, Aqueous Phase Transformations: p-Acetylaminophenol, 3-Aminopyridine, Anthranilic Acid, Benzoin, n-butyl Bromide, Cycloheptanone, 2,4-Dihydroxy Benzoinc Acid, Hippuric Acid, Pinacolone, Miscellaneous Transformations in Water.

Module-II(08 Hours)

Transformations in Solid Phase: 2-Allyl Phenol, Anthraquinone, Benzil, 2,5-Dimethylpyrrole, Flavone, Applications: Oxidation of Alcohols to Carbonyl Compounds, Oxidation of Sulphides to Sulphoxides, Pinacol-Pinacolone Rearrangement, Beckmann Rearrangement, Crossed Cannizzaro Reaction. Cis-azobenzene, Benzopinacol, Maleic Acid, cis-Stilbene,

Module-III(08 Hours)

Photochemical Transformations: Applications: Photochemical Cycloaddition Reactions, Paterno-Buchi Reaction, Photoinduced Substitution, Photochlorination, Photochemical Reaction in Solid State.

Module-IV (08 Hours)

Transformations Using Phase Transfer Catalysis: Benzoic Acid, Benzonitrile, n-butyl Benzyl Ether, 4,6-dimethyl-3-phenyl Coumarin, Flavone, Phenylisocyanide, Salicylaldehyde, Applications: Benzoin Condensation, Darzen's Reaction, Michael Reaction, Williamson Ether Synthesis, Wittig Reaction, Wittig Horner Reaction.

Module-V (08 Hours)

Transformations Using Sonication: Benzyl Cyanide, Biphenyl, Cannizzaro Reaction, Cinnamaldehyde, Cyclohexanone, Ethyl Phenyl Ether, Applications: Hydrolysis of Nitriles, Solvolysis, Strecker Synthesis, Reformatsky Reaction, Curtius Rearrangement, Oxymercuration of Olefins, Dieckmann Cyclisation, Isomerization of Maleic Acid to Fumaric Acid.

Books Recommended:

1. V.K. Ahluwalia, Green Chemistry: Greener Alternatives to Synthetic Organic Transformations, 1st Edition, Alpha Science International, 2011.
2. M. Lancaster, Green Chemistry: An Introductory Text, 2nd Edition, Royal Society of Chemistry, 2010.
3. R.A. Sheldon, I. Arends, and U. Hanefeld, Green Chemistry and Catalysis, 1st Edition, Wiley-VCH, 2007.
4. J.H. Clark and D.J. Macquarrie, Handbook of Green Chemistry and Technology, 1st Edition, Blackwell Science, 2002.
5. M.C. Cann and M.E. Connelly, Real World Cases in Green Chemistry, American Chemical Society, 2000.
6. P.T. Anastas and T.C. Williamson, Green Chemistry: Designing Chemistry for Environment, ACS Symposium Series No.: 626, American Chemical Society, 1996.
7. C.A.M. Afonso and J.G. Crespo, Green Separation Processes: Fundamentals and Applications, John Wiley and Sons, 2005.

Course Outcomes:

CO1: To Analyze Organic Transformations and familiarize in the field of ecofriendly processes.

CO2: To Plan organic transformations even in solid phase.

CO3: To implement advanced techniques by modifying the existing classical methodologies.

CO4: Designing an atom economical synthetic methodology for the organic compounds, which are important for both industry and the academy.

CO5: Incorporating the present scenario in the Transformations Using Sonication.

Course Articulation Matrix

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

Core Lab 03 Code:ICH04005 Subject: Inorganic Lab-I Credits: 2[0-0-3]

1. Estimation of Calcium by Precipitation as Oxalate and Standardization of $KMnO_4$ using Sodium Oxalate.
2. Estimation of Ferrous and Ferric Ion in a Mixture using Standard $K_2Cr_2O_7$.
3. Estimation of Copper Iodometrically and Standardization of Thiosulphate with $K_2Cr_2O_7$ Solution.
4. Estimation of Chlorine using Volhard's Method (Ferric Alum Indicator).
5. Determine the strength of Silver nitrate by Volhard's method
6. Estimation of Barium Volumetrically.

Books Recommended:

1. A.I. Vogel and J. Bassett, Vogel's Textbook of Quantitative Inorganic Analysis: Including Elementary Instrumental Analysis, 4thEdition, Longman, 1980.
2. G. Raj, Advanced Practical Inorganic Chemistry, 24thEdition, Dynamic Printer, 2012.
3. G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5thEdition, John Wiley and Sons, 1989.
4. A.K. De and A.K. De, Inorganic Chemistry and Analysis, 2ndEdition, New Age International, 2005.
5. A.K. Nad, B. Mahapatra, and A. Ghoshal, Advances Course in Practical Chemistry, 3rdEdition, New Central Book, 2011.

Course Outcomes:

CO1: Evaluate and define the precipitation as Oxalate and Standardization of $KMnO_4$ using Sodium Oxalate.

CO2: Express the Ferrous and Ferric Ion in a Mixture using Standard $K_2Cr_2O_7$

CO3: Define and demonstrate the Chlorine using Volhard's Method.

CO4: Compile the strength of Silver nitrate by Volhard's method.

CO5: Analyze and evaluate the Barium Volumetrically.

Course Articulation Matrix

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

CO4	2	3	3	2	3	2
CO5	2	3	3	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	2	3	3	2	3	2

Core Lab 04 Code:ICH04006 Subject: Organic lab-II Credits: 2[0-0-3]

1. Synthesis of Benzene Azo Beta Naphthol.
2. 2.Synthesis of Acetone Oxime.
3. Synthesis of Dibenzalacetone.
4. Synthesis of Benzopinacol usingPhotochemical transformation.
5. Synthesis of Aspirin.
6. Synthesis of Iodoform.
7. Synthesis of Indigo.
8. Synthesis of Acetanilide.
9. Separation of organic compounds (alcohol and acid) using TLC.
10. Separation of aromatic compounds using TLC.

Books Recommended:

1. V.K. Ahluwalia, R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, 1st Edition, University Press, 2000
2. N.K. Vishnoi, Advanced Practical Organic Chemistry, 2nd Edition, Vikas Publishing, 2009.
3. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, and A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, ELBS Longman, 1996.
4. F.G. Mann and B.C. Saunders, Practical Organic Chemistry, 4th Edition, Pearson Education, 2009.

Course Outcomes:

CO1: To analyze the principles of Organic reaction procedures.

CO2: To develop the concepts behind the separation of organic compounds.

CO3: To analyze the principles behind the identifications of different organic compounds.

CO4: To organize the radicals into different groups.

CO5: To demonstrate and use the different reagents in organic synthesis.

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	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	2	3	2	2

05th SEMESTER

Core 09 Code:ICH05001 Subject: Analytical Instrumentation MethodsCredits: 4[3-1-0]

Module-I (08 Hours)

Introduction to electromagnetic radiation and its interaction with atoms and molecules.

UV-Visible Spectroscopy: Absorption Law,theory of Electronic Spectroscopy, Types of Electronic Transition, Origin of Molecular Spectra, Factors Affecting Absorption Maxima, Instrumentation, Empirical Calculation for Absorption Maxima for Dienes and Enones. Woodward-Fieser Rules, Problems involved.

Module-II(08 Hours)

IR spectroscopy: Introduction, Range of IR Radiation, Requirements for IR Absorption, Modes of Vibration of Atom in Polyatomic Molecules, Vibrational Frequency and Factors Affecting It, Single Beam and Double Beam Spectrophotometer Application to Organic and Inorganic Compounds

Module-III(08 Hours)

NMR spectroscopy: Principle of NMR, Classical Descriptionof NMR, Instrumentation, Chemical Shift, Spin-Spin Coupling,Coupling Constant, Application of NMR Spectroscopy to Simple Organic Compounds.

Module-IV(08 Hours)

Mass Spectroscopy: Basic Principle, Instrumentation, Types of Ions produced in a Mass Spectrophotometer, Determination of Molecular Formula, Fragmentation, Identification of the Mass Spectra of Simple Organic Compounds such as Hydrocarbons (Aliphatic, Aromatic, Cycloalkanes), Aliphatic Alcohols (P,S,T), Aldehydes and Ketones, Carboxylic Acids.

Module-V(08 Hours)

Chromatography: Principle, Classification, Rf Value, Column Chromatographs (Introduction, Adsorbents, Classification to Adsorbents, Eluents, Preparation, Separation of Component and Application), Paper Chromatography (Introduction, Stationary Phase, Solvents, Mechanism, Separation of Components), Ascending, Descending and Radial Paper Chromatography, Thin Layer Chromatography, Gas-Liquid Chromatography and High Performance Liquid Chromatography (Preliminary Idea).

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: Analyze the interaction of UV-Vis radiation with matter and apply the response of interaction in calculating the absorption maxima.

CO2: Able to analyze IR spectra of different samples and determine the functional group composition of the compounds.

CO3: Apply NMR technique in structure elucidation of simple organic molecule.

CO4: Define the basic concept of Mass spectrometry in structure elucidation.

CO5: Demonstrate various types of chromatographic techniques in separation and analysis.

Course Articulation Matrix

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

Core 10 Code:ICH05002 Subject: Bioinorganic Chemistry Credits: 4[3-1-0]

Module-I (08Hours)

Essential and Trace Metals: Role of Alkali and Alkaline Earth Metal Ions, Na^+-K^+ Pump,Ionophores and Crown Ethers: Metal Site Structure.

Module-II(08Hours)

Function and Model Systems of the Following,**Metal Ion Transport and Storage:** Ferritin, Transferrin, Siderophores andMetallothionein.

Module-III (08Hours)

Metal Ions in Biology: Their Vital Role in the Active-Site Structure and Function of Metalloproteins and Enzymes Especially Those Containing Mg, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, and W Ions.

Heme and Non-heme Systems with One-, Two- or Multi-metal Centres (e.g., Fe: Hb, Mb, Hr, P-450, MMO, Ferridoxins, and Fe-S Clusters).

Module-IV (08Hours)

Cu: Hemocyanin, SOD, **Mn:** Vitamin B12, **Zn:** CPA, CA, **Ni:** Urease will also be highlighted. Focus will be on the Metal Environment (Ligand Type, Coordination, and Geometry), Electronic, Magnetic, and Redox Properties.

Module-V(08Hours)

Oxygen Transport and Storage: Hemoglobin, Myoglobin, Hemerythrin, Hemocyanin. **Oxygen Activation:** Cytochrome P450, Cytochrome C Oxidase. Others: Catalase, Peroxidase, Superoxide Dismutase, Alcohol Dehydrogenase, Carbonic Anhydrase, Carboxypeptidase, Xanthine Oxidase, Nitrogenase, Vitamin B12 Coenzyme, Photosystem I and II, Oxygen Evolving Centre.

Books Recommended:

1. S.J. Lippard and J.M. Berg, Principles of Bioinorganic Chemistry, University Science, Books, 1994.
2. K.H. Reddy, Bioinorganic Chemistry, 1st Edition, New Age international, 2003.
3. A.K. Das, Bioinorganic Chemistry, 3rd Edition, Books and Allied, 2013.
4. P.S. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, 2nd Edition, NewAge International, 2010.

5. I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, Bioinorganic Chemistry, University Science Books, 1994.
6. G.L. Eichhorn, Inorganic Biochemistry, Volume I and II, Elsevier, 1973.
7. J.J. Lippard, Progress in Inorganic Chemistry Volume 18 and 38, John Wiley and Sons, 1986.
8. R.R. Crichton, Biological Inorganic Chemistry: A New Introduction to Molecular Structure and Function, 2nd Edition, Elsevier, 2012.
9. W. Kaim and B. Schwederski, and A. Klein,Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide, 2nd Edition, John Wiley and Sons, 2013.

Course Outcomes:

CO1: Define and demonstrate about essential and trace metals and its application.

CO2: Evaluate and analyze the function and transport of metal ions.

CO3: Demonstrate and express about heme and non-heme system.

CO4: Define and evaluate about ligand and their geometry.

CO5: Apply the fundamentals principle of bio-cycle.

Course Articulation Matrix

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

Elective-I Code:ICH05003 Subject: Solid Sate Chemistry Credits: 4[3-1-0]

Module-I(08 Hours)

Crystal Structure: Crystalline and Amorphous Solids; Crystal Systems.

Point Groups: Methods of Characterizing Crystal Structure - Powder X-ray Diffraction, Electron and Neutron Diffraction; Types of Close Packing - HCP and CCP, Packing

Efficiency, Radius Ratios; Polyhedral Description of Solids; Structure Types - NaCl, ZnS, Na_2O, $CdCl_2$, Wurtzite, Nickel Arsenide, CsCl, CdI_2, Rutile and Cs_2O, Perovskite ABO_3, K_2NiF_4, Spinels.

Module-II(08 Hours)

Preparative Methods: Solid State Reaction, Chemical Precursor Method, Co-precipitation, Sol-Gel, Metathesis, Self-propagating High Temperature Synthesis, Ion Exchange Reactions, Intercalation/Deintercalation Reactions; Hydrothermal and Template Synthesis; High Pressure Synthesis.

Module-III(08 Hours)

Characterization:

Thermal Analysis:TGA, DTA, DSC

Optical properties: Luminescence of d- and f- block Ions, Structural Probes, Up and Down Conversion Materials.

Electrical Properties: Band Theory of Solids-Metals and their Properties;

Module-IV(08 Hours)

Semiconductors- Extrinsic and Intrinsic, Hall Effect; Thermoelectric Effects (Thomson, Peltier and Seebeck); Insulators- Dielectric, Ferroelectric, Pyroelectric and Piezoelectric Properties; Ionic Conductors.

Module-V(08 Hours)

Magnetic Properties: Dia, Para, Ferro, Ferri, and Antiferro Magnetic Types; Soft and Hard Magnetic Materials; Select Magnetic Materials such as Spinels, Garnets and Perovskites, Hexaferrites and Lanthanide-Transition Metal Compounds; Magnetoresistance.

Books Recommended:

1. A.R. West, Solid State Chemistry and Its Applications, 1st Edition, John Wiley and Sons, 1984.
2. H.B. Keer, Principles of the Solid State, 1st Edition, New age International, 1993.
3. N.B. Hannay, Solid-state Chemistry, 1st Edition, Prentice-Hall, 1967.
4. D.K. Chakrabarty, Solid State Chemistry, 2nd Edition, New Age Science, 2010.

Course Outcomes:

CO1: Give a qualitative description of bonding in solid materials, crystal classes and symmetries as a basis for space groups. Give a qualitative description of old and new concepts to describe the structure of inorganic solids.

CO2: To have an idea about different methods for the synthesis of inorganic solid materials

CO3: Give a proper understanding of thermal and optical properties of solids

CO4: Understand the structure and used of semiconductor

CO5: Give a qualitative representation of the relationship between structure/bonding and electronic, electrical, and magnetic properties of solids with emphasis on some of the most important classes of inorganic materials.

Course Articulation Matrix

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

Elective-II Code:ICH05004 Subject: Polymer Chemistry Credits: 4[3-1-0]

Module-I(08 Hours)

Polymer,Importance of Polymer, Monomer and Repeat Unit,Degree of Polymerization, Classification of Polymers, Functionality, Crystallinity, Amorphous and Crystalline Polymer, Glass Transition Temperature, Effect of Plasticizer, Copolymer, Chemical Structure, Molecular Weight, Chain Topology, Chain Branching and Crosslinking on T_g. Crystalline Melting Point of Polymer, Copolymer and Types of Copolymer, Ionic Copolymerization, Bulk Copolymer and Its Type. Classification of Polymerization.

Module-II(08 Hours)

Step Growth and Chain Growth Polymerization, Kinetics of Linear Condensation Polymerization, Kinetics of Free Radical Addition Polymerization, Molecular Weight Control in Linear Polymerization, Molecular Weight Distribution in Linear Polymerization. Polyaddition Polymerization, Vulcanization of Rubber.

Module-III(08 Hours)

Radical Chain Polymerization, Cationic Chain Polymerization, Kinetics of Cationic Chain Polymerization, Anionic Chain Polymerization, Kinetics of Anionic Chain Polymerization, Inhibitors, Retarders, Co-ordination Polymerization. Ring Opening Polymerization,

Qualitative Picture, Quantitative Aspects, Mechanism and Other Characteristics of Emulsion Polymerization.

Module-IV(08 Hours)

Stereo Isomerism in Polymers, Properties of Stereo Regular Polymers, Polymer Molecular Weight, Different Types of Polymer Molecular Weight, Polydispersity and Molecular Weight Distribution, Significance of Molecular Weight, Determination of Molecular Weight by end Group Analysis, Viscometry, Osmometry and Light Scattering Method, Copolymer Composition,Kinetics of Copolymerization, Applications of Copolymerization

Module-V(08 Hours)

Deformation and Fracture in Polymers, Behaviour of Adhesives. Conducting Polymers, Biomedical Polymers, importance, Uses, Advantages and Disadvantages of Bioactive polymers, Fire Retardant Polymers, Polymers used in Contact Lens and Artificial Heart Devices, Dental Polymers.

Books Recommended:

1. F.W. Billmeyer Jr., Textbook of Polymer Science, 3rdEdition, John Wiley and Sons, 2008.
2. R.J. Young and P.A. Lovell, Introduction to Polymers, 3rdEdition, CRC Press, 2011.
3. H.R. Allcock and F.W. Lampe, Contemporary Polymer Chemistry, 2ndEdition, Prentice Hall, 1990.
4. G. Odian, Principles of Polymerisation, 4thEdition, John Wiley and Sons, 2004.
5. L. H. Sperling, Introduction to Physical Polymer Science, 4thEdition, John Wiley and Sons, 2006.
6. M.P. Stevens, Polymer Chemistry: An Introduction, 3rdEdition, Oxford University Press, 2009.
7. C.E. Carraher Jr., Introduction to Polymer Chemistry, 3rdEdition, CRC Press, 2013.

Course Outcomes:

CO1: Analyze the relationships between polymer molecular weight, molecular weight distribution, and the properties of polymeric materials.

CO2: Demonstrate an ability to distinguish different polymerization reactions and their mechanisms/kinetics, and analyze how actual polymerization processes.

CO3: Analyze polymer molecular weights and molecular weight distributions from different types of experiments.

CO4: Design and expand their skills in performing and analysing the thermal and mechanical properties of polymers, and demonstrate an ability to predict how the molecular weight will affect these properties.

CO5: Demonstrate the viscoelastic behaviour of polymers with respect to their chemical structures and molecular weights, and to construct a corresponding master curve from the experimental data, which can be used to predict the material response at different temperatures, times, and/or frequencies.

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

Core Lab 05 Code:ICH05005 Subject: I Polymer Chemistry Lab Credits: 2[0-0-3]

1. Purification of Monomers.
2. Synthesis of Polyacrylonitrile.
3. Synthesis of Polymethylmethacrylate.
4. Synthesis of Polyazylacetate.
5. Synthesis of Higher Molecular Weight Linear Polymers.
6. Thermal Polymerization of Acrylmonomer.

Course Outcomes:

CO1: To purify Monomers by removing Impurities.

CO2: To analyze the Rate of the Reaction.

CO3: To synthesize Different Polymers based on Acrylic Monomers.

CO4: Characterize the Polymeric Products.

CO5: Design New Polymeric Materials and Determination of its Molecular Weight.

Course Articulation Matrix

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

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

Core Lab 06 Code: ICH05006 Subject: Inorganic Lab-II Credits: 2[0-0-3]

1. Gravimetric Analysis of Nickel as Dimethylglyoxime.
2. Gravimetric Estimation of Barium as $BaSO_4$ in $BaCl_2$ Solution
3. Gravimetric estimation of Copper as Copper Thiocyanate.
4. Estimation of Iron and Nickel in a given Solution.
5. Estimation of Iron and Magnesium in a given Solution.
6. Estimation of Copper and Magnesium in a given Solution.

Books Recommended:

1. A.I. Vogel and J. Bassett, Vogel's Textbook of Quantitative Inorganic Analysis: Including Elementary Instrumental Analysis, 4thEdition, Longman, 1980.
2. G. Raj, Advanced Practical Inorganic Chemistry, 24thEdition, Dynamic Printer, 2012.
3. G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5thEdition, John Wiley and Sons, 1989.
4. A.K. De and A.K. De, Inorganic Chemistry and Analysis, 2ndEdition, New Age International, 2005.
5. A.K. Nad, B. Mahapatra, and A. Ghoshal, Advances Course in Practical Chemistry, 3rdEdition, New Central Book, 2011.

Course Outcomes:

CO1: Evaluate and express Nickel as Dimethylglyoxime.

CO2: Express the Barium as BaSO4 in barium chloride solution.

CO3: Demonstrate and write the Copper as Copper thiocyanate.

CO4: Compile the Iron and Nickel in a Given solution.

CO5: Analyze and evaluate the Copper and Magnesium in a given solution.

Course Articulation Matrix

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

06th SEMESTER

Core 11 Code:ICH06001 Subject: Natural Products Credits: 4[3-1-0]

Module-I(06 Hours)

Natural Pigment: Natural Colouring Matter, General Classification, Synthesis of Anthocyanins (Cyanine), Flavones (Chryosin) and Flavanol (Querecetin)

Module-II(06 Hours)

Porphyrin: Structure, Spectral Properties, Biological Importance and Synthesis of Haemoglobin and Chlorophyll-A.

Module-III(10 Hours)

Alkaloids: General Method of Structure Elucidation of Alkaloids, Structure Elucidation of Quinine, Biological Importance and Synthesis of Morphine.

Vitamins: Introduction, Synthesis and Biochemical Importance of Vitamin B_1 (Thiamine), Vitamin H (Biotin), Vitamin E (α-Tocopherol), and Vitamin C (Ascorbic Acid).

Module-IV(08 Hours)

Steroids and Hormones: Introduction and Stereochemistry of Steroids, Structure Elucidation of Cholesterol, Biological Importance of Bile Acid.

Brief Biological Importance of Androgens, Oestrogens, Gestrogens, Adrenocortical Hormones and Cortisone.

Module-V (10 Hours)

Terpenoids: Classification, Nomenclature, General Methods of Structure Determination, Structure Elucidation of Abietic Acid, Synthesis and Biological Importance of Farnesol, Zingeberine and Squalene.

Books Recommended:

1. I.L. Finar, Organic Chemistry, Volume I and II, 6th Edition, Pearson Education, 2002.
2. S.F. Dyke, The Chemistry of Vitamins, 1st Edition, Interscience Publishers, 1965.
3. K.W. Bantely, The Chemistry of Natural Products, Volume 1–10, Interscience Publishers, 1957.
4. L.G. Wade Jr., Organic Chemistry, 8th Edition, Prentice Hall, 2012.
5. O.P. Agrawal, Organic Chemistry Natural Products, Volume I and II, 42nd Edition, Krishna Prakashan, 2013.

Course Outcomes:

CO1: Helps in understanding the pharmacological importance of natural pigments.

CO2: Helps in understanding the structure of porphyrin and related biological compounds.

CO3: Students will have an idea of biological importance of alkaloid and vitamins along with their structure and properties .

CO4: Helps in understanding the utilization and functions of various Steroids and the structure, bonding, and biological importance of selected hormones.

CO5: Define the classification and description of terpenoidsalong with their structure elucidation .

Course Articulation Matrix

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

Core 12 Code: ICH06002Subject: Advanced Environmental Chemistry Credits: 4[3-1-0]

Module-I (08 Hours)

Air Pollutants and Sources (Natural andManmade), Air Quality Standards, Control of Air Pollution from Stationary Sources by Change of Raw Materials, Process Change

andEquipment Modification. Control of Air Pollution by Adopting Controlling Engineering Devices such as Wet Scrubbers, Dry Scrubbers, Wet Filters, Dry Filters andElectrostatic Precipitators, Effects of Pollutants on Man andMaterials.

Module-II (08 Hours)

Water World, Water Quality Standards andClassification of Water with respect to Quality Criteria, Conventional Methods of Water Treatments (Coagulation, Sedimentation, Filtration and Disinfections), and DrinkingWater Treatment by Electro-dialysis, Ion Exchange, Reverse Osmosis and Terracotta Filtration Methods, Waste Water Treatment by Modern Water Engineering System by Primary Treatment, Secondary Treatment (Biological), Activated Sludge System.

Module-III (08 Hours)

Waste in Environment: Solid, Liquid andGaseous Waste, Household Waste, Municipal Waste, Industrial Waste, Mining Waste, Hazardous and Radioactive Waste, Biomedical Waste Management for Sustainable Environment.

Module-IV (08 Hours)

Environmental Management System: Environmental Impact Assessment andManagement Process (EIAandEMP), Base Line Data Generation and Assessment of Environmental Impact for Air ,Water, Noise, Soil, Land, Forest, Flora, Fauna, and Meteorology, Environmental Management System with respect to Various Pollutants (Air, Water, Noise, and Soil), Rehabilitation,Restoration,andReclamation,Environmental Audit and ISO Certification (14000 Series).

Module-V (08 hours)

Environmental Laws: Water Pollution and Control Act 1974, Air Pollution and Control Act 1981, Environmental Protection Act 1986, Function andResponsibilities of Ministry of Environment and Forest (MOEF), Central Government, Central Pollution Control Board andState Pollution Control Board, Forest Conservation Act 1980, Process of Environmental Clearance of New and Old Projects.

Books Recommended:

1. S.E. Manahan, Environmental Chemistry, 9thEdition, CRC Press, 2010.
2. A.K. De, Environmental Chemistry, 2ndEdition, New Age International, 2006.
3. J.H. Vandermeulen and S.E. Hrudey, Oil in Freshwater: Chemistry, Biology, Countermeasure Technology, 1st Edition, Pergamon Press, 1987.
4. M.C. Dash, Ecology,Chemistry and Management of Environmental Pollution, 1st Edition, MAC Millan, 2004.

5. H.M. Dix, Environmental Pollution: Atmosphere Land Water and Noise, 1st Edition, John Wiley and Sons, 1981.
6. J.C. Crittenden, R.R. Trussell, D.W. Hand, K.J. Howe, and G. Tchobanoglous, MWH's Water Treatment: Principles and Design, 3rd Edition, John Wiley and Sons, 2012.
7. S.K. Garg, Sewage disposal and air pollution engineering, 11th Edition, Khana Publishers, 1998.
8. S.V.S Ranna, Essential of Ecology and Environmental Science,2nd Edition, Prentice Hall, 2008.
9. B. Pani, Textbook of Environmental Chemistry, 1st Edition, I.K. International, 2007.
10. M.D. LaGrega, P.L. Buckingham, and J.C. Evans, Hazardous Waste Management, 2nd Edition, Waveland Press, 2010.
11. L.K. Wang, Y.-T. Hung, and N.K. Shammas, Handbook of Advanced Industrial and Hazardous Wastes Treatment, 1st Edition, CRC Press, 2010.
12. J. Pichtel, Waste Management Practices: Municipal, Hazardous, and Industrial, 2nd Edition, CRC Press, 2014.
13. G. Woodside, Hazardous Materials and Hazardous Waste Management, 2nd Edition, John Wiley and Sons, 1999.
14. C. Ray and R. Jain, Drinking Water Treatment: Focusing on Appropriate Technology and Sustainability, 1st Edition, Springer, 2011.
15. B.J. Finlayson-Pitts and J.N. Pitts Jr., Chemistry of the Upper and Lower Atmosphere: Theory, Experiments, and Application, 1st Edition, Academic Press, 2000.
16. M.M. Varma and J.H. Johnson, Hazardous and Industrial Waste: Proceedings of the Twentieth Mid-Atlantic Industrial Waste Conference, Hazardous Materials Control Research Institute (HMCRI), 1988.

Course Outcomes:

CO1: To prepare trained work force in environmental chemistry to serve the country in the field of environmental management. In addition, the work force can work for the growth of nation in the field of environmental regulating bodies such as Central and State pollution control board and industries for better environmental management and sustainable development

CO2: The course is designed in such a way that it will cover the entire field of chemistry and full- fill the gap of basic knowledge of students in chemistry.

Developed expertise relevant to the professional practice of chemistry, environmental science and engineering

CO3: Developed an understanding of the range and chemistry of compounds in the hydrosphere and geosphere. Established an appreciation of the role of chemistry in environmental science. Developed knowledge on the role of the chemist in measurement and problem solving in environmental studies

CO4: Plan on chemical methods employed for environmental problem solving Experience in some scientific methods employed in environmental chemistry Developed skills in procedures and instrumental methods applied in analytical tasks of environmental chemistry

CO5: Developed skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments. Developed an understanding of the professional and safety responsibilities residing in working on environmental problem

Course Articulation Matrix

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

Elective-IIICode:ICH06003Subject: Principles of Inorganic Chemistry Credits: 4[3-1-0]

Module-I (08 Hours)

Theory of Acid-Bases: Arrhenius Theory, Solvent-System Definition, Brönsted-Lowry Theory: Conjugate Acid-Base Pairs, Lewis Theory, Usanovich Concept, Lux-Flood concept, Acid-Base Equilibrium, Strength of Brönsted Acids and Bases: Gas-Phase Proton Affinity, Acid and Bases in Water, Levelling Effect of Water, Lewis Acid and Bases: Properties.

Module-II (08 Hours)

Hard and Soft Acids and Bases: Pearson's Classification, HSAB Principle, Symbiosis Effect, strength of Lewis Acids and Bases, Super Acids: Hammett-Acidity Function.

Oxidation-Reduction Reaction: Basic Concepts, Redox Reactions and Electromotive Force, Electrochemical Cells, Type of Electrodes, Electrode Potential: Standard Electrode Potential,

Formal Potential, Factors Influencing Electrode Potential: Effect of Concentration, p^H, Precipitation, Complex Formation.

Module-III (08 Hours)

Application of Electrode Potential: Electrochemical Series, Redox Stability in Water, Redox Potential Diagram: Latimer Diagram (Disproportionation Reaction: Chlorine, Manganese System, Copper System, Oxidation by Atmospheric Oxygen), Frost Diagram (Manganese), Redox Titration: Redox Indicator, Titration of Fe(II) by $KMnO_4$, Titration of Fe(II) by $K_2Cr_2O_7$.

Module-IV (08 Hours)

Theoretical Principles in Qualitative Analysis:H_2S Scheme, Basic Principles involved in Analysis of Cations and Anions and Solubility Products, Commonion Effect,Principles involved in Separation of Cations into Groups and Choice of GroupReagents, Interfering Anions (Fluoride, Borate, Oxalate,and Phosphate) and Need to Removethem after Group II.

Module-V (08 Hours)

Inorganic Rings, Chains and Cages and Clusters: Definitions, Electron Deficient, Electron Precise, and Electron Rich Compounds,Catenation and Heterocatenation, Heterocyclic Ring System- Borazines, Phosphazines, Monomer and Polymer, S-N Ring Compounds, Homocyclic Rings of S, Se and Te. Silicate Minerals, Isopolyanions, Boranes: Boron Cage Compounds-Closo, Nido, Arachno, Carboranes; Cage Compounds of S and P.

Books Recommended:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry - Principles of Structure and Reactivity, 4th Edition, Pearson Education, 2006.
2. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Edition, Oxford University Press, 2010.
3. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, Blackwell Science, 1996.
4. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson, 2004.
5. A. G. Sharpe, Inorganic Chemistry, 3rd Edition, Pearson, 2010.
6. C. E. Housecraft and A. G. Sharpe, Inorganic Chemistry, 4th Edition, Pearson, 2012.
7. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edition, John Wiley and Sons, 2008.
8. B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edition, John Wiley and Sons, 2010.
9. S. Prakash, G.D. Tuli, S.K. Basu, R.D. Madan, Advanced Inorganic Chemistry: Volume 1, 18th Edition, S. Chand, 2000.

10. R. P. Sarkar, General and Inorganic Chemistry: Part 1, 3rd Edition, New Central Book Agency, 2011.

Course Outcomes:

CO1: To understand the basic theories of acids and bases.

CO2: To understand the basics principle, theory hard and soft acid base and to explain the theories of oxidation –reduction reaction.

CO3: Derive the stability field of water and use this to rationalize aqueous redox chemistry, to construct and be proficient with Latimer diagrams and Frost diagrams, using them to determine unknown reduction potential values and to quickly identify stable and unstable species.

CO4: To understand the basic principle and theories of qualitative analysis.

CO5: To explain the basics of inorganic cages and clusters.

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	3	3	3	3
CO4	3	3	3	3	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	3	3	3	3

Core Lab 07 Code:ICH06005 Subject: Advanced Physical Lab Credits: 2[0-0-3]

Any six from the following

1. Determination of Concentrationof Unknown Dextrose Solution by Polarimeter.
2. Viscosity Determination by Ostwald Viscometer.
3. Determination of Cell Constant of Conductivity Cell.
4. Conductometric Titration of Strong Acid-Strong Base.
5. To study of an Equilibrium $KI + I_2 = KI_3$.
6. To study the Simultaneous Equilibria in Benzoic Acid - Benzene Water System.
7. Verification of Beer's Lambert Law and Unknown Concentration Determination.

8. Determination of Equivalent Conductance of a Strong Electrolyte Conductometrically.
9. Determination of Critical Solution Temperature (Phenol Water System).

Course Outcomes:

CO1: Analyze the optical activity of chemical using polarimeter.

CO2: Evaluate the viscosity of samples using viscometer.

CO3: Analyze the samples by means of conductometer.

CO4: Evaluate the equilibrium phenomenon of the physical systems.

CO5: Application of spectroscopy for qualitative and quantitative analysis.

Course Articulation Matrix

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

07th SEMESTER

Core 13 Code: ICH07001 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_N2, S_N1, Mixed S_N1 and S_N2, 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. Eğe, 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
Course	3	2	2	2	1	1

Core 14 Code: ICH07002 Subject: 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-Saunder's Coupling, j-j Coupling, Ground State Term Symbols and Hund's Rule, Micro States and Derivation of Russel-Saunder'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, 6th Edition, Prentice Hall, 2008.
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 Outcomes 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 15 Code: ICH07003 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 16 Code: ICH07004 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

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

Core Lab 08 Code: ICH07005 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.

Course Outcomes:

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

Core Lab 09 Code: ICH07006 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

08th SEMESTER

Core 17 Code: ICH08001 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 18Code: ICH08002 Subject: Organic Reaction Mechanism Credits: 3 [4-0-0]

Module-I (10 Hours)

Alipahatic 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 19 Code: ICH08003 Subject: Organometallics Credits: 4 [3-1-0]

Module-I (08 Hours)

Compounds of Transition Metal Carbon Multiple Bonds (Alkylidines, Alkylidynes, Low Valent Carbenes and Carbines: Synthesis Nature of Bonding and Structural Characteristics, Nucleophillic 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
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 20 Code: ICH08004 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. Aruldhas, 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

Core Lab 10 Code: ICH08005 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($HCl+CH_3COOH$) with base (NaOH)
4. Determination of solubility product of $BaSO_4$.
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 Cu^{2+}.
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 Inc., 1984.
2. J.M. Wilson, R.J. Newcombe, and A.R. Denaro, Experiments in Physical Chemistry, 2nd Edition Pergamon, 1968.

Course Outcomes:

CO 1: Apply the principles of physical chemistry in the quantitative analysis.

CO 2: Evaluate the end point of a titration by instrumental technique.

CO 3: Demonstrate and use the different instruments including Conductivity meter, potentiometer, colorimeter, PH meter, UV-Visible spectrophotometer, polarimeter, etc. in analysis.

CO 4: Analyze kinetics of different reactions.

CO 5: 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

Core Lab 11 Code: ICH08006 Subject: Environmental and Analytical Lab Credits: 2 [0-0-3]

Any Six from the Following:

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 (SOx and NOx) 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. Kebbekus, 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

09thSEMESTER

Core 21 Code:ICH09001 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.

Electrocyclic reactions: 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, 1,3 Dipolar 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, Trimethyl Sillyl Iodide, Tri-n-butyl Tin Hydride, Osmium Tetroxide, Selenium Dioxide, Phase Transfer Catalysis (Crown Ether, Merrifield Resin, Wilkinson's Catalyst), Dichloro Dicyano 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, 4thEdition, 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 22 Code: ICH09002 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 ^{1}H 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.

Core Lab 12 Code: ICH09003 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 theflash 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

10th 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

List of Electives:

Code: ICH09004 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 (08 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 Annelation.

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: ICH09005 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: ICH09006 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: ICH09007 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: ICH09008 **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: ICH09009 Subject: Industrial Process Credits: 4 [3-1-0]

Module-I (8 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 (6 Hours)

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

Module-IV (6 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 SmecticMesophases. 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: ICH10004 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 Phosphoros, Sulphur, Silicon or Boron: Introduction, Phosphoros 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:ICH10005 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 Kreb'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 Pyramidines 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, Phosphoenol Pyruvate, 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, 5thEdition, 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 Education, 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: ICH10006 **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-Triazoies,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. Syntheis of Caffeine, Theobromine and theophylline.

Module-V (08 Hours)

Larger Ring and other Heterocycles: Synthesis and Structure of Azepines, Oxepines and Thiepines. Synthesis of Diazepines Rearrangements of 1,2-Diazepines. Synthesis of Benzoazepines, Benzodiazepines, Benzooxepines, Benzothiepines, Azocines and Azonines. Synthesis of selenophenes, Tellerophenes, 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 Endition, 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 routs 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

Code: ICH10007 **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
5. Edition, Springer, 2013.
6. G.W. Gray, Thermotropic Liquid Crystals, 1st Edition, John Wiley and Sons, 1987.
7. H. Kelker and R. Hatz, Handbook of Liquid Crystals, 1st Edition, Verlag Chemie, 1980.
8. 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.
9. C.S. Sunandana, Introduction to Solid State Ionics: Phenomenology and Applications, 1st Edition, CRC Press, 2016.
10. T. Torres and G. Bottari, Organic Nanomaterials: Synthesis, Characterization, and Device Applications, 1st Edition, John Wiley and Sons, 2013.
11. M. Ohring, Materials Science of Thin Films: Deposition and Structure, 2nd Edition, Academic Press, 2002.
12. 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
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: ICH10008 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: ICH10009 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 Micellazation, 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. Rajgopalam, 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:ICH10010 **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 x(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 Hartee-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 Real World 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: ICHOE904 **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 & 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