Course of Studies

for

5 Year Integrated Master of Science (Int. M.Sc.)

in

Chemistry

(Session 2016 – 2017 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

Programme Objective:

- The proposed course aims to provide students with a broad theoretical background in Inorganic, Organic & Physical Chemistry, with emphasis on Analytical Techniques.
- Particular attention is given to Industrial applications of chemistry so that students are completely equipped to move into careers in academic, industrial and commercial organizations. The course curriculum is interdisciplinary in nature.
- The content of the course provides an understanding of different aspect of chemistry. The lecture based course will cover the various aspects of pure & applied chemistry.
- In lab experiments the emphasis is laid on green chemistry and increasing the use of semi-micro, and micro techniques.
- Laboratory courses have been designed to provide an exhaustive and hands on experience on working with various sophisticated instruments.
- Final semester is dedicated to thesis/dissertation work giving students experience in solving a real-life problem under the supervision of faculty members involved in pursuing research and development projects.

Programme Outcome:

- Students should have an advanced level understanding of at least three of the following areas of chemistry - Analytical, Inorganic, Organic, and Physical Chemistry. They should have a graduate level understanding of their major area(s) of research.
- Students should broaden their professional foundations through activities such as teaching, internships, and fellowships.
- Students should be able to communicate scientific results in writing and in oral presentation.
- Students should acquire the basic tools needed to carry out independent chemical research.
- Students should become proficient in their specialized area of chemistry and successfully complete an advanced research project.

Course Structure of 5 Year Integrated M.Sc. (Chemistry)

First Semester

Sl. No.	Course Code	Name of the Course	L–T–P	Credit
1	CH–111	Chemistry–I (General)	3–1–0	04
2	PH–111	Physics–I	3–1–0	04
3	MAT–111	Mathematics–I	3–1–0	04
4	BIO–111	Biology–I	3–1–0	04
5	HS–111	English–I	3–1–0	04
6	CH–112	Chemistry Lab–I	0–0–3	02
7	PH–112	Physics Lab–I	0–0–3	02
8	HS–112	Language Lab–I	0–0–3	02
9	MAT–112	Mathematics Lab–I	0–0–3	02
			Total Credits	**28**

Second Semester

1	CH–121	Chemistry–II (Basic Inorganic–I)	3–1–0	04
2	PH–121	Physics–II	3–1–0	04
3	MAT–121	Mathematics–II	3–1–0	04
4	BIO–121	Biology–II	3–1–0	04
5	CS–121	Computer Science	3–1–0	04
6	CH–122	Chemistry Lab–II	0–0–3	02
7	PH–122	Physics Lab–II	0–0–3	02
8	CS–122	Computing Lab–I	0–0–3	02
9	HS–122	Language Lab–II	0–0–3	02
			Total Credits	**28**

Third Semester

1	CH–211	Chemistry–III (Basic Physical–I)	3–1–0	04
2	CH–212	Environmental Science	3–1–0	04
3	HS–211	Organizational Behaviour	3–1–0	04
4	PH–211	Physics–III	3–1–0	04
5	MAT–211	Mathematics–III	3–1–0	04
6	CH–213	Organic Chemistry Lab–I	0–0–3	02
7	CH–214	Environmental Science Lab	0–0–3	02
8	PH–212	Physics Lab–III	0–0–3	02
9	CS–211	Computing Lab–II	0–0–3	02
			Total Credits	**28**

Fourth Semester

1	CH–221	Chemistry–IV (Basic Organic–I)	3–1–0	04
2	CH–222	Basic Inorganic Chemistry–II	3–1–0	04
3	HS–223	Economics & Costing	3–1–0	04
4	PH–221	Physics–IV	3–1–0	04
5	MAT–221	Mathematics–IV	3–1–0	04
6	CH–223	Physical Chemistry Lab–I	0–0–3	02
7	CH–224	Instrumentation Lab	0–0–3	02
8	PH–222	Physics Lab–IV	0–0–3	02
9	MAT–222	Mathematics Lab–II	0–0–3	02
			Total Credits	**28**

Fifth Semester

1	CH–311	Basic Organic Chemistry–II	3–1–0	04
2	CH–312	Solid State Chemistry	3–1–0	04
3	CH–313	Green Chemistry	3–1–0	04

4	CH–314	Bioinorganic Chemistry	3–1–0	04
5	CH–315	Chemistry of Industrial Materials	3–1–0	04
6	CH–316	Inorganic Lab–I	0–0–3	02
7	CH–317	Organic Lab–II	0–0–3	02
			Total Credits	**24**

Sixth Semester

1	CH–321	Natural Products	3–1–0	04
2	CH–322	Basic Physical Chemistry–II	3–1–0	04
3	CH–323	Principle of Inorganic Chemistry	3–1–0	04
4	CH–324	Analytical Instrumental Methods	3–1–0	04
5	CH–325	Biomolecules	3–1–0	04
6	CH–326	Inorganic Chemistry Lab–II	0–0–3	02
7	CH–327	Polymer Chemistry Lab	0–0–3	02
			Total Credits	**24**

Seventh Semester

1	CH–411	Group Theory & Wave Mechanics	4–0–0	04
2	CH–412	Coordination Chemistry	4–0–0	04
3	CH–413	Structure & Reactivity	4–0–0	04
4	CH–414	Thermodynamics & Chemical Dynamics	4–0–0	04
5	CH–415	Polymer Chemistry	4–0–0	04
6	CH–416	Inorganic General Lab.	0–0–3	02
7	CH–417	Organic General Lab.	0–0–3	02
			Total Credits	**24**

Eighth Semester

1	CH–421	Analytical Chemistry	4–0–0	04

2	CH–422	Stereochemistry	4–0–0	04
3	CH–423	Spectroscopy–I	4–0–0	04
4	CH–424	Organic Reaction Mechanism	4–0–0	04
5	CH–425	Surface Chemistry & Nuclear Chemistry	4–0–0	04
6	CH–426	Physical General Lab.	0–0–3	02
7	CH–427	Analytical Lab.	0–0–3	02
			Total Credits	**24**

Ninth Semester

1	CH–511	Organometallics	4–0–0	04
2	CH–512	Photochemistry & Pericyclic Reaction	4–0–0	04
3	CH–513	Spectroscopy–II	4–0–0	04
4	CH–514	Environmental Chemistry	4–0–0	04
5	CH–515	Supramolecular Chemistry	4–0–0	04
6	CH–516	Industrial Lab.	0–0–3	02
7	CH–517	Environmental Lab.	0–0–3	02
			Total Credits	**24**

Tenth Semester

1	CH–521	Solid State & Nanomaterials	4–0–0	04
2	CH–522	Chemistry of Materials	4–0–0	04
3	CH–523	Organic Synthesis	4–0–0	04
4	CH–524	Seminar	–	02
5	CH–525	Project	–	08
6	CH–526	Industrial Training report	–	02
			Total Credits	**24**

SEMESTER: 1st

Code: **CH-111** Subject: **CHEMISTRY-I** Credits: **4 [3-1-0]**

Course Objective:

- Explain the behaviour of, and interactions between, matter and energy at the atomic and molecular levels.
- Use standardized names and symbols to represent atoms, molecules, ions and chemical reactions.
- Predict atomic structure, chemical bonding or molecular geometry based on accepted models.
- Apply quantitative reasoning skills to determine quantities of matter and energy involved in physical and chemical changes.
- Explain the behaviour of, and interactions between, matter and energy at the atomic and molecular levels.

Course Outcome:

- Apply the fundamental principles of measurement, matter, atomic theory, chemical periodicity, chemical bonding, general chemical reactivity and solution chemistry to subsequent courses in science, engineering, technology, allied health and various other related disciplines that depend upon these principles for successful comprehension.
- Apply essential chemical concepts and math skills toward successful completion of future science and applied science and engineering courses.

Module I: (10 Hours)

Atomic Structure and Wave Mechanics: De-Broglie Matter Waves, Heisenberg's Uncertainty Principle and its Verification, Schrödinger's Wave Equation, Significance of Wave Equation, Schrödinger's Equation for the Hydrogen Atom (Solution of the Equation for Hydrogen Atom is not required) θ, φ, and R Equations, Quantum Numbers and their Significance. Concept of Radial and Angular Wave Functions, Spherical Harmonics (Mathematical Derivation is not required).

Module II: (10 Hours)

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

Module III: (10 Hours)

Electronic Effects and Organic Reaction Intermediates: Distribution of Electron in Organic Molecules, Inductive Effect, Resonance and Hyperconjugation (Conditions, Effect of Electron Withdrawing and Donating Groups, Steric Effect, Influence on Acidity, Basicity and Dipole Moment), Reaction Intermediates (Formation, Stability, and Structure) (i) Carbocation, (ii) Carbanion, (iii) Free Redical, and (IV) Carbene.

Module IV: (10 Hours)

Introduction to Polymer Chemistry: Introductory Concepts, Definition, Common System Chemistry and Classification of Polymers, Resins, Rubber, Plastics. Characterization: Molecular Weight Studies and Molecular Weight Distribution. Mechanistic Aspects: Addition, Ionic and Condensation Polymerization, Polymerization Techniques: Coordination Polymerisation and Copolymerisation (Introduction to Free Radical and Ionic Polymerisation).

Prescribed Books:

1. P. Atkins and J. de Paula, *Elements of Physical Chemistry*, 6th Edition, Oxford University Press, 2013.

2. J. Singh and L.D.S. Yadav, *Advanced Organic Chemistry*, 7th Edition, Pragati Prakashan, 2011.

3. V.R. Gowarikar, J. Sreedhar, and N.V. Viswanathan, *Polymer Science*, 1st Edition Reprint, New Age International, 2005.

Referred Books:

1. J. Clayden, N. Geeves, and S. Warren, *Organic Chemistry*, 2nd Edition, Oxford University Press, 2012.

2. J.E. Huheey, E.A. Keiter, R.L. Keiter, and O.K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education, 2009.

3. B.R. Puri, L.R. Sharma, and M.S. Pathania, *Principles of Physical Chemistry,* 46th Edition, Vishal Publishing, 2013.

Code: **CH-112** Subject: **CHEMISTRY LAB-I** Credits: **2 [0-0-3]**

Course Objective:

- To provide hands-on opportunities to develop fundamental laboratory analytical skills and apply this knowledge in executing project work and solving basic industrial problems in future.

Course Outcome:

- Develop knowledge of concepts and applications of chemistry, important laboratory techniques, methods, and instrumentation.
- Common laboratory techniques including pH measurement, acid/base titrations, UV/Visible spectroscopy in both emission and absorption mode. How to carry out self-directed experiments practical laboratory experiments.

1. Determinations of Hardness of Water.

2. Determinations of Percentage Purity of Lime Stone Sample.

3. Determinations of Dissolved Oxygen in Water.

4. Determinations of Sodium Carbonate & Sodium Bicarbonate Content in a Mixture.

5. Determinations of Sodium Carbonate & Sodium Hydroxide Content in a Mixture.

6. Determinations of Iron Content in a Sample.

Prescribed Books:

1. P.K. Kar, S. Dash, and B. Mishra, *B. Tech. Practical Chemistry,* 1st Edition, Kalyani Publishers, 2005.

SEMESTER: 2nd

Code: **CH-121** Subject: **Chemistry-II** Credits: **4 [3-1-0]**

Course Objective:

- To introduce certain key aspects of inorganic chemistry, including solid state structures, the chemistry of Group 15 and materials and transition metal chemistry.
- To provide practice in answering some basic concepts in inorganic chemistry through assessed problem sheets.
- Apply current chemistry models/theories to understand and predict the physical/electronic properties, bonding, and reactivity that occur in inorganic complexes with emphasis on coordination complexes containing transition metals.
- Construct qualitative sets of molecular orbitals for simple molecules and inorganic complexes.

Course Outcome:

- To develop expertise relevant to the professional practice of chemistry.
- To establish an appreciation of the role of inorganic chemistry in the chemical sciences.
- To develop an understanding of the role of the chemist in measurement and problem solving in inorganic chemistry.
- To provide an understanding of chemical methods employed for problem solving involving inorganic systems.
- To provide experience in some scientific methods employed in inorganic chemistry.
- To develop skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
- To develop some understanding of the professional and safety responsibilities residing in working with inorganic systems.

Module-I: (10 Hours)

Chemical Bonding*:*

Ionic Bond: General Characteristics, Born Equation and its Applications, Polarisability, Fajan's Rule, Percentage of Ionic Character from Dipole Moment and Electronegativity Difference, Hydration and Salvation Energy.

Covalent Bond: Valence Bond Approach, Hitler-London Treatment of H_2 Molecule (Mathematical Treatment Excluded), Concept of Resonance and Resonance Energy,

Directional Characteristics of Covalent Bond, Concept of Hybridisation, Valence Shell Electron Pair Repulsion (VSEPR) Theory, Deductions of Geometry of Following Type of Molecules from Hybridisation AB_2, AB_3, AB_2E_1, AB_4, AB_3E_1, AB_2E_2, AB_5, AB_4E_1, AB_3E_2, AB_2E_3, AB_6, AB_5E_1, AB_4E_2, AB_7, AB_6E_1 (where E Represents Lone Pair of Electrons)

Qualitative Treatment of MOT: Bonding, Anti-bonding and Non-bonding Molecular Orbitals, MO Configuration of H_2, N_2, O_2, CO, NO, HX and their Ions.

Module-II: (10 Hours)

Compounds of p-Block Elements (Preparation and Structure):

Boron Family: Boric Acid, Hydrides of Boron and Borazole

Carbon Family: Carbides, Silanes, Silicates and Silicones.

Nitrogen Family: Hydrides of Nitrogen

Oxygen Family: Oxygen Fluorides, Per Acids of Sulphur

Halogen Family: Oxides and Oxyacids of Chlorides, Inner Halogen Compounds

Module-III: (10 Hours)

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

Module-IV: (10 Hours)

Coordination Compounds: Ligands, Coordination Number, Coordination Sphere, Nomenclature, Werner Coordination 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.

Prescribed Books:

1. J.D. Lee, *Concise Inorganic Chemistry*, 5^{th} Edition, John Wiley & Sons, 2008.

2. S. Prakash, G.D. Tuli, S.K. Basu, and R.D. Madan, *Advanced Inorganic Chemistry:*

Volume 1, 18th Edition, S. Chand & Sons, 2000.

Referred Books:

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.

Code: **CH-122** Subject: **CHEMISTRY LAB- II** Credits: **2 [0-0-3]**

Course Objective:

- To provide the students a competence in the laboratory skills required for accurate and precise chemical analysis.
- The students will know the theoretical basis of qualitative inorganic analysis containing common and less common ions.

Course Outcome:

- The student will gain the laboratory skills to estimate quantitatively by using complexometric and redox titrations.
- The student can confirm the presence of less common and common ions in the mixtures using semimicroanalysis.

Qualitative Analysis of Mixtures of Inorganic Substances Containing not More than Four Radicals (Interfering Acid Radicals Like CO_3^{2-}, SO_3^{2-}, S^{2-}, NO^{2-}, Cl^-, Br^-, PO_4^{3-}, AsO_3^{3-}, NO^{3-}, I^-, SO_4^{2-}).

Prescribed Books:

1. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Pearson Education, 2009.

2. A.K. De and A.K. De, *Inorganic Chemistry and Analysis*, 2nd Edition, New Age International, 2005.

SEMESTER: 3rd

Code: **CH-211** Subject: **Chemistry-III (Basic Physical-I)** Credits: **4 [3-1-0]**

Course Objective:

- The course aims to provide a rigorous basic understanding of dilute solutions, homogeneous equilibrium, chemical kinetics and thermodynamics.

- Students are required to apply mathematical skills (derivations and integrations) and basic physics to understand chemical reactions and related processes.
- Students will gain a good foundation of knowledge and skills for further study in Physical Chemistry.

Course Outcome:

- Describe various properties of dilute solutions like boiling point, freezing point, osmotic pressure, vapour pressure etc.
- Explain chemical equilibrium processes involved in a chemical reaction.
- Gain a clear information regarding order and molecularity of various simple reaction and complex reactions.
- Learn fundamental chemical thermodynamics and be able to use this in experimental and theoretical work with chemical systems.

Module-I: (10 Hours)

Dilute Solutions: Vapour Pressure, Raoult's 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: (10 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: (10 Hours)

Chemical Kinetics: Order and Molecularity, Kinetics of I^{st} and II^{nd} Order Reactions, Simple Opposing (A & B) Reaction, Consecutive of Sequential (A-B-C) Reaction, Chain Reaction (H_2+Br_2). Effect of Temperature on Reaction Rate. Collision Theory of Reaction Rate, Qualitative Treatment of Transition Theory.

Module-IV: (10 Hours)

Thermodynamic Concept: Heat Content and Heat Capacity Isothermal and Adiabaic Change,

Work Done for Ideal and van der Waal Gases.

Thermochemistry: Heat Changes in Chemical Reactions, Hess's Law, Kirchoff's Equation.

2nd law of Thermodynamics: Spontaneous Process, Carnot's Theorem and Carnot's Cycle, Efficiency of Heat Engine, Entropy Changes in Reversible and Irreversible Processes, Free Energy and Work Function Condition for Equilibrium, Clapeyron and Clausius Equation, Gibb's Helmholtz Equation.

Prescribed Books:

1. P. Atkins and J. de Paula, *Elements of Physical Chemistry*, 6th Edition, Oxford University Press, 2013.

2. P. Atkins and J. de Paula, *Physical Chemistry*, 9th Edition, W. H. Freeman, 2009.

3. R.A. Alberty and R.J. Silbey, *Physical chemistry*, 2nd Edition, John Wiley & sons, 1997.

4. T. Engel and P. Reid, *Physical Chemistry*, 3rd Edition, Pearson Education, 2012.

5. K.J. Laidler, J.H. Meiser, and B.C. Sanctuary, *Physical Chemistry*, 4th Edition, Houghton Mifflin, 2003.

Referred Books:

1. G.N. Barrow, *Physical Chemistry*, 5th Edition, Tata McGraw-Hill, 2007.

2. K.L. Kapoor, *A Textbook of Physical Chemistry*, 2nd Edition, Macmillan, 2011.

3. H. Kuhn, H.-D. Försterling, and D.H. Waldeck, *Principles of Physical Chemistry*, 2nd Edition, John Wiley & sons, 2009.

4. R.G. Mortimer, *Physical Chemistry*, 3rd Edition, Elsevier, 2008.

5. I.N. Levine, *Physical Chemistry*, 6th Edition, McGraw-Hill, 2008.

6. G.W. Castellan, *Physical Chemistry*, 3rd Edition, Addison Wesley, 1983.

Code: **CH-212** Subject: **ENVIRONMENTAL SCIENCE** Credits: **4 [3-1-0]**

Course Objective:

- 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.

Course Outcome:

- Students will aware about their environment and also will get related service in environmental management in industries and regulating officer.

Module-I: (10 Hours)

Scope of Ecology, Component of Ecosystem, Concept and Definition of Environmental Pollution, Types and Classification of Pollution, Pollution and Source of Pollution. History of Major Pollution Episodes.

Air pollution: Concept of Hydrosphere, Concept of Atmosphere and its Pollution, Major and Minor Pollutants in Atmosphere (SO_x, NO_x, CO_2, Fluoride, Hydrocarbon).

Module-II: (10 Hours)

Water Pollution: Classification and Types of Water Pollution. Industrial Waste, Municipal Waste, Agriculture Chemicals, Oil Pollution, Heavy Metals Ground Water Pollution (Mercury, Lead, Arsenic).

Module-III: (10 Hours)

Acid Rain, Photochemical Smog, Greenhouse Effect and Ozone Layer Depletion, Eutrophication, Ecological Magnification.

Soli Pollution: Concept of Lithosphere, Sources of Soil Pollution, Pollution Effect of Pesticides and Fertilizer in Soil. Use of Flora for Control of Pollution.

Module-IV: (10 Hours)

Pollution by radiation: Sources of Radioactive Pollution, Effect of Radiation Protection and Control from Radiation, Disposal of Radioactive Waste.

Pollution due to Noise: Sources of Noise, Noise Levels in Decibel Scale, Effect of Noise on Human Health, Prevention and Control of Noise.

Prescribed Books:

1. S.E. Manahan, *Environmental Chemistry*, 9th Edition, CRC Press, 2010.

2. A.K. De, *Environmental Chemistry*, 2nd Edition, 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.

Code: **CH-213** Subject: **ORGANIC CHEM LAB-I** Credits: **2 [0-0-3]**

Course Objective:

- To provide a platform to carryout different fundamental experiments related to identification, purification, isolation, extraction, and preparation of organic compounds.

Course Outcome:

- Identify the Functional Groups present in a supplied organic compound.
- Purify of Organic Solvents Using Distillation.
- Carry out the separation of mixture of organic compounds using chromatography.
- Dry the Organic Solvents using different drying agents.
- Prepare some organic compounds such as Picric Acid and Benzoin.
- Extract of Caffeine from Tea Leaf and Casein from Milk.
- Isolate Piperine from Black Pepper.

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 Picric Acid and Benzoin.

6. Extractions of Caffeine from Tea Leaf.

7. Extractions of Casein from Milk.

8. Isolation of Piperine from Black Pepper.

Prescribed Books:

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, Longman, 1996.

Referred Books:

1. P.R. Singh, D.S. Gupta, K.S. Bajpai, *Experimental Organic Chemistry, Volume 2, Qualitative and Quantitative Analysis*, Tata McGraw-Hill, 2004.

2. A. Ault, *Techniques and Experiments for Organic Chemistry, 6th Edition,* University Science Books, 1998.

CH-214 ENVIRONMENTAL SCIENCE LAB 2 Credits [0-0-3]

Course Objective:

- The course describes and gives hands on experience about different environmental related practical to the students

Course Outcome:

- Determination of alkalinity and residual chlorine, fluorides and arsenic in a water sample.
- Determination of COD, COD and TDS and CO_2 in a water sample.
- Determination of phosphate and sulphate in sewage sample.
- Determination of Cu^{2+}, Fe^{2+}, Fe^{3+}, Cr^{6+} and Pb^{2+} by spectroscopic method.

1. Determination of Alkalinity in Water Sample.

2. Determination of Moisture, pH and Conductivity of Soil Sample.

3. Determination of Turbidity using Nephelo Tubidity Meter.

4. Determination of TDS in Water Sample.

5. Determination of Residual Chlorine in Drinking Water.

6. Determination of COD of a Water Sample.

7. Determination of BOD of a Water Sample.

8. Determination of Cu^{2+}, Fe^{2+}, Fe^{3+}, Cr^{6+} and Pb^{2+} by Spectroscopic Method.

9. Estimation of Fluoride and Arsenic in Ground Water.

10. Determination of CO_2 in Water Sample.

Prescribed Books:

1. B. Mishra, S. Dash, and P.K. Kar, *B.Tech. Practical Chemistry*, 1st Edition, Kalyani Publishers, 2005.

2. J.N. Gurtu and A. Gurtu, *Advanced Physical Chemistry Experiments*, 8th Edition, Pragati Prakashan, 2015.

SEMESTER: 4th

Code: **CH-221** Subject: **CHEMISTRY-IV (BASIC ORGANIC-I)** Credits: **4 [3-1-0]**

Course Objective:

- To provides a bridge between basic and more advanced organic chemistry knowledge. It also makes connection from chemical principles to the structures and functions of different organic molecules.

Course Outcome:

- Understand the formation, stability and structure of different reaction intermediate.
- Able to identify the type of reaction and mechanism.
- Knowledge of the basic mechanisms of substitution and elimination (Sn1, Sn2, E1, E2, E1cb, electron transfer)
- Understanding the basic concepts of kinetics as applied to organic chemistry.
- Naming and identifying the structures including configurational isomers(stereo-isomers and geometric isomers) and conformational isomer.
- Apply sterochemical aspects to reaction mechanism.
- Know the synthetic application of different organic compounds such as Grignard's Reagent and Esters Containing Active Methylene Groups.
- Learn the preparation and reactions of different compounds Carbohydrates, Aryl Nitrogen Compounds, Nitro Hydrocarbons, Acyclic Compounds, Five Membered heterocyclics

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: (10 Hours)

Stereochemistry:

Configurational Isomerism: Optical Isomerism: Introduction, Conditions for Optical Activity, Optical Rotation, Specific Rotation, D & L Convention, R & S Notations, Optical Isomers of Lactic, and Tartaric Acids, Enantiomers and Diastereomers, Threo and Erythro Nomenclature, Meso Compounds, Racimic Modification, Methods of Resolution.

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

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

Module-III: (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 Felhings Solution, Mutarotaion, Elucidation of Structure of D-Glucose (Open Chain and Ring Structure).

Module-IV: (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.

Prescribed Books:

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. Geeves, 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 & Sons, 2014.

5. L.G. Wade Jr., *Organic Chemistry*, 8th Edition, Prentice Hall, 2012.

Referred Books:

1. S.K. Ghosh, *Advanced General Organic Chemistry: A Modern Approach: Volume I and II*, 3rd Edition, New Central Book, 2010.

2. J.E. McMurry, *Organic Chemistry*, 8th Edition, Brooks/Cole, 2012.

3. T.N. Sorrell, *Organic Chemistry*, 2nd Edition, University Science Books, 2006.

4. D.R. Klein, *Organic Chemistry*, 2nd Edition, John Wiley & Sons, 2013.

5. J.M. Hornback, *Organic Chemistry*, 2nd Edition, Thomson Brooks/Cole, 2006.

Code: **CH-222** Subject: **BASIC INORGANIC CHEMISTRY-II** Credits: **4 [3-1-0]**

Course Objective:

- To introduce the concepts underlying Metal-Ligand Bonding in Metal Complexes.
- An overview of the thermodynamic, kinetic and magnetic aspects of metal complexes**.**
- To impart the knowledge of f-block elements (lanthanides and actinides).
- Studies of the organometallic chemistry and inorganic polymer.

Course Outcome:

- Give a qualitative description of metal-ligand bonding in octahedral, tetrahedral and square planar complexes along with their magnetism and color.
- Give a qualitative description of thermodynamic stability of the complexes and reaction in square planar complexes.
- A brief discussion about the determination of the magnetism in the complexes and its application
- Give an overview of the chemistry of different aspects of lanthanides and actinides.
- Impart the knowledge of organometallic chemistry with special emphasize on their synthesis and applications.
- Give an overview of the inorganic polymer along with their applications

Module-I: (10 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 the Colour of the Coordination Compounds on the Basis of the Theory, John-Teller Effect in Octahedral Complexes.

Module-II: (10 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, Methods of Determining Magnetic Susceptibility, 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: (10 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 Chemistry of Cerium.

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

Module – IV: (10 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, Ni, Effective Atomic Number Rule.

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 (liq. NH_3 and Liq SO_2).

Prescribed Books:

1. J.D. Lee, *Concise Inorganic Chemistry*, 5th edition, Blackwell, 2008.

2. J.E. Huheey, E.A. Keiter, R.L. Keiter, and O.K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education, 2009.

3. G.L. Miessler and D.A. Tarr, *Inorganic Chemistry*, 3rd Edition, Pearson Education, 2004.

4. R. Sarkar, *General and Inorganic Chemistry: Part I and II*, 3rd Edition, New Central Book, 2011.

Referred Books:

1. D. Shriver, M. Weller, T. Overton, F. Armstrong, and J. Rourke, *Inorganic Chemistry*, 6th Edition, W.H. Freeman, 2014.

2. B.W. Pfennig, *Principles of Inorganic Chemistry*, 1st Edition, John Wiley & Sons, 2015.

3. J.E. House, *Inorganic Chemistry*, 1st Edition, Academic Press, 2008.

4. E.Wiberg, N. Wiberg, *Inorganic Chemistry*, 1st Edition, Academic Press, 2001.

Code: **CH-223** Subject: **PHYSICAL CHEM LAB-I** Credits: **2 [0-0-3]**

Course Objective:

- To expose students about different laboratory experiments related to quantitative analysis and titrimetric experiments

Course Outcome:

- The students will be having hand-on experience of kinetics of a reaction, gravimetric and Conductometric experiments for quantitative analysis.

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.

Prescribed Books:

1. R.C. Das and B. Behera, *Experimental Physical Chemistry*, 1st Edition, Tata McGraw-Hill, 1984.

2. P.S. Sindhu, *Practical's in Physical Chemistry: A Modern Approach*, 1st Edition, Macmillan, 2006.

Referred Books:

1. B.P. Levitt, *Findlay's Practical Physical Chemistry*, 9th Edition, Longman, 1973.

Code: **CH-224** Subject: **INSTRUMENTATION LAB** Credits: **2 [0-0-3]**

Course Objective:

- To carryout simple chemical reaction which would be monitored by Electroanalytical and Spectrophotometric Techniques

Course Outcome:

- The student will be exposed to various analytical techniques like Conductometry, Potentiometry, Spectrophotometry and X-ray Diffraction

Simple Experiments will be conducted to Elucidate the Working Principles, Instrumentation and Handling of Gas Chromatograph, UV-Vis Spectrometer, IR Spectrometer, Polarimeter, Conductivity Meter, pH Meter and Nephlometer.

Prescribed Books:

1. R.C. Das and B. Behera, *Experimental Physical Chemistry*, 1st Edition, Tata McGraw-Hill, 1984.

2. P.S. Sindhu, *Practical's in Physical Chemistry: A Modern Approach*, 1st Edition, Macmillan, 2006.

Referred Books:

1. B.P. Levitt, *Findlay's Practical Physical Chemistry*, 9th Edition, Longman, 1973.

SEMESTER: 5th

Code: **CH-311** Subject: **BASIC ORGANIC CHEMISTRY-II** Credits: **4 [3-1-0]**

Course Objective:

- To provides a bridge between basic and more advanced organic chemistry knowledge. It also makes connection from chemical principles to the structures and functions of different organic molecules.

Course Outcome:

- Understand the detail mechanism, stereochemical aspect and effect of different factors on the nucleophilic substitution reaction.
- Able to accomplish the Conformational Analysis of cyclohexanes.
- Learn the preparation, reactions and structure elucidation of different organic compounds such as six membered heterocyclics, Polynuclear Hydrodcarbons, Fused Heterocycles: Urides and Purines, Indigo etc.
- Know about the isolation, structural elucidation, synthesis and application of some natural products such as Alkaloids, Terpenes, and Vitamins.
- Understand the mechanism and application of some name reaction and rearrangements.
- Understand the application of some reagents such as $LiAlH_4$, $NaBH_4$, HIO_4, IBD, PCC and DCC in organic chemistry.

Module I: (10 Hours)

Types of Mechanisms, types of Reactions, Aliphatic Substitution Reaction: 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 disubstituted Cyclohexanes.

Module II: (10 Hours)

Heterocyclic Compounds:

Six Membered Heterocylces: Pyridine and Quinoline (Preparation and Reactions)

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

Indigo: Structure and Use.

Polynuclear Hydrodcarbons: Naphthalene and Anthracene (Addition and Electrophilic

Substitution Reactions, Elucidation of their Structures).

Module III: (10 Hours)

Alkaloids: Introduction Elucidation of Structure of Nicotine, Papavarine.

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

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

Module IV: (10 Hours)

Mechanism and Applications: Pinacole-Pinacolone, Demjanov, Dienone-Phenol, Beckmann and Benzidene, Diels-Alder, Schmidt, Lossen, Curtius Reaction

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

Prescribed Books:

1. P.Y. Bruice, *Organic Chemistry*, 3rd Edition, Pearson Education, 2009.

2. T.W.G. Solomons, C.B. Fryhle, and S.A. Snyder, *Organic Chemistry*, 11th Edition, John Wiley & Sons, 2014.

3. R.K. Bansal, *Heterocyclic Chemistry*, 3rd Edition, New Age International, 2005.

Referred Books:

1. T.L. Gilchrist, *Heterocyclic Chemistry*, 3rd Edition, Pearson Education, 2008.

2. S.K. Ghosh, *Advanced General Organic Chemistry: A Modern Approach: Volume I and II*, 3rd Edition, New Central Book, 2010.

Code: **CH-312** Subject: **SOLID STATE CHEMISTRY** Credits: **4 [3-1-0]**

Course Objective:

- To provide an introduction to the concepts underlying solid state chemistry.
- An overview of the synthesis and applications of inorganic materials.
- Structure and compound identification in the solid state.
- Studies of the magnetism, electrical and optical properties of the solid state compounds

Course Outcome:

- 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.
- Give a qualitative and quantitative representation of crystal defects in crystalline solids and knowledge of defects related to non-stoichiometry in some important classes of inorganic materials.

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

Module-I: (10 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: (10 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: (10 Hours)

Characterization: Thermal Analysis - TGA, DTA, DSC Electrical Properties: Band Theory of Solids -Metals and their Properties, Semiconductors - Extrinsic and Intrinsic, Hall Effect, Thermoelectric Effects (Thomson, Peltier and Seebeck), Insulators - Dielectric, Ferroelectric, Pyroelectric and Piezoelectric Properties, Ionic Conductors.

Module-IV: (10 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.

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

Prescribed Books:

1. A.R. West, *Solid State Chemistry and Its Applications*, 2nd Edition, John Wiley & Sons, 2014.

2. H.V. 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.

5. L.E. Smart and E.A. Moore, *Solid State Chemistry: An Introduction*, 4th Edition, CRC Press, 2012.

6. R.C. Ropp, *Solid State Chemistry*, 1st Edition, Elsevier, 2003.

Code: **CH-313** Subject: **GREEN CHEMISTRY** Credits: **4 [3-1-0]**

Course Objective:

- To develop novel, efficient, convenient, selective and environmentally benign synthetic methods in organic chemistry, which helps the drug discovery and medicinal chemistry and agro chemicals.
- To provide greener and environmentally sound synthetic protocols and reaction conditions which play pivotal role in recent years towards the goal of switching to increasing efficient and benign process that avoid the use of volatile organic solvents, toxic reagents, harsh reaction conditions, as well as challenging and time consuming wasteful separations.

Course Outcome:

- Helps in developing a green processes for various chemical transformations with both homogeneous and heterogeneous catalysts and without harmful organic solvents.
- Helps in understanding the importance of water as a solvent in chemical reactions as well as reactions carried out in solvent-free conditions.

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: (10 Hours)

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

Module III: (10 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 IV: (10 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.

Prescribed Books:

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 & Sons, 2005.

Code: **CH-314** Subject: **BIO-INORGANIC CHEMISTRY** Credits: **4 [3-1-0]**

Course Objective:

- Bioinorganic Chemistry of selected topics of interest. Examples include the inorganic chemistry (and biochemistry) behind the requirement of biological cells for metals such as zinc, iron and copper; and metals in medicine such as mechanisms by which organisms obtain required metal ions from their environment, and use of metal-containing compounds in treating diseases such as cancer.

Course Outcome:

- Understand the principles and concepts of inorganic/organic chemistry in biological system.
- Understand structure, bonding, and spectral properties of selected metals in proteins and nucleic acids.
- Understand chemical mechanisms of selected metal homeostasis (i.e. uptake, transport and storage).
- Understand the role of metal complexes medicine

Module I: (10 Hours)

Essential and Trace Metals: Role of Alkali and Alkaline Earth Metal Ions, Na^+-K^+ Pump, ***Ionophores and Crown Ethers:*** Metal Site Structure, Function and Model Systems of the Following. ***Metal Ion Transport and Storage:*** Ferritin, Transferrin, Siderophores and Metallothionein.

Module II: (10 Hours)

Metal Ions in Biology: Their Vital Role in the Active-Site Structure and Function of Metallo-

Proteins 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, Fe-S Clusters).

Module III: (10 Hours)

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 IV: (10 Hours)

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 B_{12} Coenzyme, Photosystem I and II, Oxygen Evolving Centre.

Prescribed Books:

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 & Allied, 2013.

4. P.S. Kalsi, *Bioorganic, Bioinorganic and Supramolecular Chemistry*, 2nd Edition, New Age International, 2010.

Referred Books:

1. I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, *Bioinorganic Chemistry*, University Science Books, 1994.

2. G.L. Eichhorn, *Inorganic Biochemistry Vol. I & II*, Elsevier, 1973.

3. J.J. Lippard, *Progress in Inorganic Chemistry Vol. 18 & 38*, John Wiley & Sons, 1986.

4. R.R. Crichton, *Biological Inorganic Chemistry: A New Introduction to Molecular Structure and Function*, 2nd Edition, Elsevier, 2012.

5. W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the*

Chemistry of Life, 2nd Edition, John Wiley & Sons, 2006.

Code: **CH-313** Subject: **CHEMISTRY OF INDUSTRIAL MATERIALS** Credits: **4 [3-1-0]**

Course Objective:

- To introduce the chemistry (composition, structure, properties and application) of different materials of industrial importance.

Course Outcome:

- Ability to understand the detail composition, properties, manufacture process and application of different materials of industrial importance such as fuels, plastics, dyes and pigments, soap and detergent, cement and pesticides.
- Understand different concepts such as Knocking, Colour and Constitution, etc. related to the above materials.
- Understand the metal extraction process/ metallurgical operation for conversion of an ore to metals.
- Manufacturing of various inorganic and organic chemicals • Ability to understand the process flow diagram and various process parameters • Ability to identify and solve engineering problems during production.
- Distinguish various existing fuels, plastics, paints, oil and fat in day to day life.

Module-I: (10 Hours)

Fuel and Combustion: Introduction, Classification, Calorific Value, Petroleum and Coal based Chemicals: Composition of Petroleum, Cracking Processes, Knocking, Diesel Engine Fuels, Distillation of Coal tar, Water Gas, CNG, LPG, Biodiesels.

Module-II: (10 Hours)

Plastics: Types, thermosetting and thermoplastics, Moulding of Plastics.

Dyes and Pigments: Colour and Constitution, Types of Dyes and Paints, Varnishes.

Module-III: (10 Hours)

Oils and Fats: Solvent Extraction of Oils, Properties of oil, Analysis of oil and fats , Use of Oil in the Manufacturing of Soap, detergents: Classification(anionic, cationic and non-ionic) and Manufacturing of Detergents Used for Cleansing Purpose.

Module-IV: (10 Hours)

Chemistry of Cement.

Metal Extraction.

Pesticides: Preparation and uses of DDT, BHC, Parathion.

Prescribed Books:

1. M.G. Rao and M. Sittig, *Dryden's Outlines of Chemical Technology for the 21st Century*, 3rd Edition, Affiliated East-West Press, 2010.

Referred Books:

1. P.J. Chenier, *Survey of Industrial Chemistry*, 3rd Edition, Springer, 2002.

2. C.A. Clausen and G. Mattson, *Principles of Industrial Chemistry*, 2nd Edition, Wiley-Interscience, 1978.

3. B.K Sharma, *Industrial Chemistry*, Goel Publishing, 1997.

Code: **CH-316** Subject: **INORGANIC LAB-I** **Credits 2 [0-0-3]**

Course Objective:

- To provide the students a competence in the laboratory skills required for accurate and precise chemical analysis. The students will know the theoretical basis of qualitative inorganic analysis containing common and less common ions.

Course Outcome:

- The student will gain the laboratory skills to estimate quantitatively by using complexometric and redox titrations.
- The student can confirm the presence of less common and common ions in the mixtures using semimicro analysis.

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. Estimation of Barium Volumetrically.

6. Gravimetric Analysis of Nickel as Dimethylglyoxime.

Prescribed Books:

1. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Pearson Education, 2009.

2. A.I. Vogel and J. Bassett, *Vogel's Textbook of Quantitative Inorganic Analysis: Including Elementary Instrumental Analysis*, 4th Edition, Longman, 1980.

Referred Books:

1. G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Edition, John Wiley & Sons, 1989.

2. A.K. De and A.K. De, *Inorganic Chemistry and Analysis*, 2nd Edition, New Age International, 2005.

3. A.K. Nad, B. Mahapatra, and A. Ghoshal, *Advances Course in Practical Chemistry*, 3rd Edition, New Central Book, 2011.

Code: **CH-317** Subject: **ORGANIC LAB-II** Credits: **2 [0-0-3]**

Course Objective:

- To provide experience in synthesizing important organic molecules.

Course Outcome:

- Planning of a synthetic plan for organic compounds such as such as Acetone Oxime, Phenylazo -2- naphthol, Dibenzalacetone, Benzopinacol, Aspirin, acetanilide.
- Execution of the planned synthetic plane with available chemicals.
- Achieving the productivity with high purity under optimum reaction conditions.
- Understanding the green chemical principles with some organic reactions.

1. Separation of Organic Compounds.

2. Synthesis of Benzene Azo Beta Naphthol.

3. Synthesis of Benzopinacol.

4. Synthesis of Acetoneoxime.

Prescribed Books:

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.

SEMESTER: 6th

Code: **CH-321** Subject: **NATURAL PRODUCTS** Credits: **4 [3-1-0]**

Course Objective:

- To recognize the chemical building blocks in nature that enable student to link structures to biosynthetic hypotheses.
- Provides a basic knowledge on various substances such as dyes and pigments, alkaloids, vitamins, terpenoids, steroids and hormones

Course Outcome:

- Helps in understanding the pharmacological importance of various plant and animal products.
- Helps in understanding the utilization and functions of various natural products.

Module-I: (10 Hours)

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

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

Module-II: (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), α-Tocopherol (Vitamin E), and Vitamin C.

Module-III: (10 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-IV: (10 Hours)

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

Prescribed Books:

1. I.L. Finar, *Organic Chemistry, Volume I & 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*, 42th Edition, Krishna Prakashan, 2013.

6. S.V. Bhat, B.A. Nagasampagi, and M. Sivakumar, *Chemistry of Natural Products*, Springer, 2nd Edition, 2006.

7. R. Cooper and George Nicola, *Natural Products Chemistry: Sources, Separations and Structures*, 1st Edition, CRC Press, 2014.

8. R. Xu, Y. Ye, and W. Zhao, *Introduction to Natural Products Chemistry*, 1st Edition, CRC Press, 2012.

9. K.A. Solomon, *Chemistry of Natural Products*, 1st Edition, MJP Publishers, 2012.

10. R.H. Thomson, *The Chemistry of Natural Products*, 2nd Edition, Chapman & Hall, 1994.

11. J.J. Li and E.J. Corey, *Total Synthesis of Natural Products: At the Frontiers of Organic*

Chemistry, 1st Edition, Springer, 2012.

12. G.R. Chatwal, *Organic Chemistry of Natural Products, Volume I & II*, 1st Edition, Himalaya Publishing, 1994.

Code: **CH-322** Subject: **BASIC PHYSICAL CHEMISTRY-II** Credits: **4 [3-1-0]**

Course Objective:

- Understand and apply the laws of thermodynamics and kinetics.
- Understand the role that thermodynamics and kinetics play in chemical equilibrium.
- Understand how mathematics, models and approximations are used to explainchemical phenomena and fundamental properties of matter.
- Use concepts of thermodynamics/kinetics/equilibrium to make predictions and give explanations about chemical systems and fundamental properties of matter.
- Develop skills in making decisions in the lab, in data acquisition, and critical evaluation of data.

Course Outcome:

- Explain the behaviour of, and interactions between, matter and energy at the atomic and molecular levels.
- Understand the principles of kinetics and thermodynamics as applied to rates and equilibrium positions of chemical reactions.
- Use quantitative measures of solution concentration in describing colligative, acid-base, solubility, and electrochemical principles of aqueous solutions.
- Culture a basic understanding of how computational chemistry can be used to determine atomic and molecular properties.
- Apply probability principles to the behaviour of large ensembles of atoms or molecules, and to use this to predict thermodynamic properties of a system.
- Thermodynamics: Develop a competent knowledge of classical thermodynamic principles, compare these to those from statistical mechanics, and apply them to a variety of phase (gas, liquid, solid, and solution) and reaction equilibria.
- Examine basic principles of kinetics, and tie thermodynamics and kinetics together rudimentary.

Module-I: (10 Hours)

Law of Independent Migration of Ions, Ionic Velocities and Mobilities, Weak and Strong Electrolytes, Arrhenius Theory, Debye-Huckel Theory (Qualitative Idea Only).

Application of Conductance, Measurement for Determination of Solubility and Solubility Product, Degree of Ionization, Ionic Product of Water, Hydrolysis Constant.

Transference Number and its Determination by Hittorf`s Method, and Moving Boundary Method, Conductometric Titration.

Module-II: (10 Hours)

Electrochemistry: Galvanic Cell, Cell Reaction, Reversible Electrode, Thermodynamic Parameter of Reversible Cell, Nernst Equation and Expression of Single Electrode Potential, Reference Electrode (Calomel, Hydrogen, Silver Chlorides), Redox Potential, Concentration Cell with and without Transference, Liquid Junction Potential, Determination of Solubility Product, Ionic Product of Water and Mean Ionic Activity Coefficient of Electrolyte.

Module III: (10 Hours)

Equilibrium in Electrolyte: Acids and Bases, Bronsted and Lowry theory, Determination of pH by EMF Method (Hydrogen, Quinhydorne and Glass Electrode).

Hammet Acidity Function: Buffer Solution, Henderson Equation, Acid Base Indicator and Indicator Constants, Neutralization Curves.

Module-IV: (10 Hours)

Photochemistry: Beer`s Lamberts Law, Grethus Drapper Law, Stark-Einstein Law of Photochemical Equivalence, Quantum Yield, Comparison Between Thermal and Photochemical Reactions, Decomposition of HI and HBr, Elementary Idea about Photosensitized Reaction and Photosynthesis (Jablonsky Diagram, Fluorescence and Chemiluminescence, Bioluminescence, Phosphorescence)

Prescribed Books:

1. A. Bahl, B.S. Bahl, and G.D. Tuli, *Essential of Physical Chemistry*, 19th Edition, S. Chand & Sons, 2012.

2. B.R. Puri, L.R. Sharma, and M.S. Pathania, *Principles of Physical Chemistry*, 46th Edition, Vishal Publishing, 2013.

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*, 23rd Edition, S. Chand & Sons, 2014.

Code: **CH-323** Subject: **PRINCIPLE OF INORGANIC CHEMISTRY** Credits: **4 [3-1-0]**

Course Objective:

- The objective of course deals with the acids and bases theories, oxidation-reduction reactions, and Inorganic rings, chains and cages and clusters.

Course Outcome:

- The student acquires overall knowledge regarding different theories to explain the acid and bases, oxidation and reduction reactions and its relevance with electrochemical reactions as well as chemical and structural aspects of ring, chain, cage and clusters of inorganic compounds.

Module-I: (12 Hours)

Acids and Bases Theories: 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, Hard and Soft Acids and Bases (Pearson's Classification, HSAB Principle), Symbiosis Effect, Strength of Lewis Acids and Bases. Super Acids: Hammet-Acidity Function.

Module-II: (14 Hours)

Oxidation-Reduction Reactions: 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, pH, Precipitation, Complex Formation. 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-III: (14 Hours)

Inorganic Rings, Chains and Cages and Clusters: Definitions, Electron Deficient, Electron Precise, and Electron Rich Compounds, Gillespie and Nyholm Rules for Predicting Structures, Homocyclic Rings of S, Se and Te, S, SN and SeN Compounds- Neutral Sulfur Rings, Cyclic Sulfur Imides, Sulfur-Nitrogen Rings and Chains (SN_x), Catenation and Heterocatenation, Heteropoly and Isopoly Anions, Electron Counting Rules for Clusters: Wade-Mingos-Lauher Rules and Extended 18 Electron Rules (mno rules), Boranes: Boron Cage Compounds- Closo, Nido, Arachno, Heteroboranes, Carboranes, Metalloboranes and Metallocarboranes, Cage Compounds of S and P, Carbonyl and Carbide Clusters.

Prescribed Books:

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 Education, 2004.

5. A.G. Sharpe, *Inorganic Chemistry*, 3rd Edition, Pearson, 2010.

6. T. Chivers and I. Manners, *Inorganic Rings and Polymers of the P-block Elements: From Fundamentals to Applications*, 1st Edition, Royal Society of Chemistry, 2009.

Referred Books:

1. C.E. Housecroft and A.G. Sharpe, *Inorganic Chemistry*, 4th Edition, Pearson Education, 2012.

2. F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, *Advanced Inorganic Chemistry*, 6th Edition, John Wiley & Sons, 2008.

3. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, 2010.

4. S. Prakash, G.D. Tuli, S.K. Basu, R.D. Madan, *Advanced Inorganic Chemistry: Volume 1*, 18th Edition, S. Chand & Sons, 2000.

5. R. Sarkar, *General and Inorganic Chemistry: Part I and II*, 3rd Edition, New Central

Book, 2011.

Code: **CH-324** Subject: **ANALYTICAL CHEMISTRY: INSTRUMENTAL METHODS** Credits: **4 [3-1-0]**

Course Objective:

- To understand the principles of Instrumentation Techniques and the applications of various analytical techniques

Course Outcome:

- Students will know the principles of various types of chromatographic techniques.
- The students will know the principles of Thermal methods, Atomic Spectroscopy and X-ray Diffraction.
- The students will know the application of instrumental techniques in various fields

Module-I: (10 Hours)

UV-Visible Spectroscopy: Origin of Molecular Spectra, Absorption law, Instrumentation Theory of Electronic Spectroscopy, Empirical Calculation for Absorption Maxima for Dienes and Enones. Woodward–Fieser Rules, Other Applications, Problems Involved.

IR Spectroscopy: Introduction Range of IR Radiation, Requirements for IR Absorption Modes of Vibration of Atom in Polyatomic Molecules, Single Beam and Double Beam Spectrophotometer, Application to Organic and Inorganic Compounds

***Module-II*:** (10 Hours)

NMR Spectroscopy: Principle of NMR, Quantum Description of NMR, Instrumentation, Chemical Shift, Spin-Spin Coupling, Application of NMR Spectroscopy to Simple Organic Compounds.

Module-III*:* (10 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.

Module-IV*:* (10 Hours)

Chromatography: Principle, Classification R_f 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), Radial Paper Chromatography, Thin Layer Chromatography, Gas Liquid Chromatography and High Performance Liquid Chromatography (Preliminary Idea).

Prescribed Books:

1. P.S. Kalsi, *Spectroscopy of Organic Compounds*, 6th Edition, New Age International, 2007.

2. R.M. Silverstein, F.X. Webster, D.J. Kiemle, and D.L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Edition, John Wiley & Sons, 2014.

3. L.D.S. Yadav, *Organic Spectroscopy*, 1st Edition, Springer, 2004.

4. W. Kemp, *Organic Spectroscopy*, 3rd Edition, W.H. Freeman, 1991.

5. Y.R. Sharma, *Elementary Organic Spectroscopy: Principles and Chemical Applications*, 5th Edition, S. Chand & Sons, 2013.

Referred Books:

1. J. Mohan, *Organic Spectroscopy: Principles and Applications*, 2nd Edition, Alpha Science International, 2004.

2. L.M. Harwood and T.D. W. Claridge, *Introduction to Organic Spectroscopy*, 1st Edition, Oxford University Press, 1996.

3. D.L. Pavia, G.M. Lampman, G.S. Kriz, and J.A. Vyvyan, *Introduction to Spectroscopy*, 5th Edition, Cengage Learning, 2015.

4. J.B. Lambert, *Organic Structural Spectroscopy*, 2nd Edition, Pearson Prentice Hall, 2011.

5. D.F. Taber, *Organic Spectroscopic Structure Determination: A Problem-based Learning Approach*, Oxford University Press, 2007.

Code: CH-325 **Subject: BIMOLECULES** **Credits: 4 [3-1-0]**

Course Objective:

- To provide basic knowledge on Bimolecules, including large macromolecules such asproteins, carbohydrates, lipids, and nucleic acids, as well as natural products.

Course Outcome: Upon successful completion of this course, students will be able to:

- Knowledge of Carbohydrate: Inter conversion reaction of aldose to ketose, chain eleongation and chain degradation, epimerization. Disaccharides: Sucrose, lactose, cellobiose, carbohydrates.
- Awareness on topics such as Proteins: Classification, primary, secondary, tertiary and quaternary structure of proteins, glycoproteins, denaturation and folding enzymes.
- Understanding the processes which involve Nucleic acid: Nitrogenous base and pentose sugars, generic errors, central dogma, and Protein synthesis.

Module-I: (10 Hours)

Carbohydrate: Ring and Open Chain Structure of Glucose and Fructose. Reactions of Glucose and Fructose. INTER Conversion Reaction of Aldose to Ketose, Chain Elongation and Chain Degradation, Epimerization.

Disaccharides: Sucrose, Lactose, Cellobiose, Carbohydrates.

Module-II: (10 Hours)

Amino Acids: Amino Acids, Structural Features, Optical Activity, Essential and Non-essential Amino Acids, Isoelectic point, Synthesis and Chemical Properties of Alpha Amino Acids.

Module-III: (10 Hours)

Proteins: Peptides and Its Structure Determination.

Polypeptides: Classification, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Glycoproteins, Denaturation and Folding Enzymes.

Module-IV: (10 Hours)

Nucleic Acid: Nitrogenous Base and Pentose Sugars, Nucleosides, Nucleotides, Chemical and Enzymatic Hydrolysis, Structure and Functions of Nucleic Acids, DNA, RNA (m-RNA, t-RNA), Overview of Gene Expression (Replication, Transcription and Translation), Genetic Acids (Origin, Wobble hypothesis and Other Important Features), Generic Errors, Central Dogma, Protein Synthesis.

Prescribed Books:

1. D.L. Nelson and M.M. Cox, *Lehlinger Principles of Biochemistry*, W.H. Freeman, 4th

Edition, 2004.

2. T.K. Lindhorst, *Essentials of Carbohydrate Chemistry and Biochemistry*, Wiley-VCH, 2nd Edition, 2003.

3. E. Conn and P. Stumpf, *Outlines of Biochemistry*, 5th Edition, John Wiley & Sons, 2009.

Referred Books:

1. U. Satyanarayan, *Biochemistry*, New Central Book, 3rd Edition, 2006.

2. J.M. Berg, J.L. Tymoczko, and L. Stryer, *Biochemistry*, W.H. Freeman, 7th Edition, 2010.

3. S.R. Mishra, *Biomolecules*, 1st Edition, Discovery Publishing, 2003.

4. G.D. Gem Mathew and P.R. Ramachandran, *Chemistry of Natural Products and Biomolecules*, 1st Edition, Vishal Publishing, 2013.

Code: **CH-326** Subject: **INORGANIC LAB-II** Credits: **2 [0-0-3]**

Course Objective:

- The principles and applications of gravimetric and volumetric analysis are reviewed in this lecture and laboratory course.
- Topics include the theory for selecting various analytical methods, separation techniques - precipitation, extraction and complexation, sources of error, data handling, and error analysis.

Course Outcome:

- The student will gain the laboratory skills to estimate quantitatively by using complexometric and redox titrations.
- The student can confirm the presence of less common and common ions in the mixtures using semimicro analysis.
- Apply the concepts learned in gravimetric analysis to: solubility equilibria,properties of precipitates, factors affecting precipitation and crystallization, methods of precipitation and theory of washing, as well as using gravimetric techniques as a method for sample separation.

1. Estimation of Iron and Chromium in a mixture using $K_2Cr_2O_7$.
2. Gravimetric estimation of Barium as $BaSO_4$.

3. Gravimetric estimation of Copper as Copper thiocyanate.
4. Separation and estimation of Mg (II) and Fe (II).
5. Separation and estimation of Mg (II) and Zn (II).

Prescribed Books:

1. S.C. Das, *Advanced Practical Chemistry*, 5th Edition, Dynamic Printer, 2012.
2. A.I. Vogel and J. Bassett, *Vogel's Textbook of Quantitative Inorganic Analysis: Including Elementary Instrumental Analysis*, 4th Edition, Longman, 1980.

Code: **CH-327** Subject: **POLYMER LAB** Credits: **2 [0-0-3]**

Course Objective:

- To provide the students with overall knowledge on the manufacturing of plastic materials, their properties, applications, processing, product design, mold design, testing & quality control, and recycling through theory as well as practical training.
- To make the students competent to take up the challenging positions in Plastics material manufacturing industries, compounding industries, processing machinery manufacturing industries through offering specialized elective subjects and industry exposure.

Course Outcome:

- This program could provide well trained professionals for the plastics and allied industries to meet the well trained manpower requirements.
- The students will get hands on experience in various aspects of plastics technology viz. plastic materials manufacturing, properties, applications, processing, product design, mold design, testing & quality control, and recycling.
- The program will help the students to take up responsibilities in production, testing, design and marketing in the plastics industries and contribute for the growth of industry.

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.

Prescribed Books:

1. F.J. Davis, *Polymer Chemistry: A Practical Approach*, 1st Edition, Oxford University Press, 2004.

SEMESTER: 7th

Code: **CH-411** Subject: **GROUP THEORY AND WAVE MECHANICS** Credits: **4 [4-0-0]**

Course Objective:

- The objective of course deals with the application of symmetry, groups and matrices in chemistry along with the application of quantum mechanics in physical models and experiments of chemical systems.

Course Outcome:

- The course delivers the fundamental knowledges of Symmetry operations and symmetry elements and its matrix representations.
- The major outcome of the quantum chemistry includes increasing accuracy of the results for small molecular systems by using different approximation methods.

Module-I: (10 Hours)

Group Theory: Symmetry Elements and Symmetry Operations, Matrix Representation of Symmetry Operation, Classes of Operations, Point Groups (C_n, C_{nv}, C_{nh}, S_n, D_n, D_{nd}, D_{nh}, T_d, O_h, $D_{\infty a}$, $C_{\infty v}$ and $D_{\infty h}$), Properties of Point Groups, Irreducible and Reducible Representation, Bases of Representation, Character of a Representation, Reduction Formula, 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

Module-II: (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, ϕ, θ 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-III: (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-IV: (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, Huckel 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)

Prescribed Books:

1. F.A. Cotton, *Chemical Applications of Group Theory*, 3rd Edition, John Wiley & Sons, 1990.

2. A. Vincent, *Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Application*, 2nd Edition, john Wiley & sons, 2001.

3. R.L. Carter, *Molecular Symmetry and Group Theory*, 1st Edition, John Wiley & Sons, 1997.

4. M. Ladd, *Symmetry and Group theory in Chemistry*, 1st Edition, Horwood publishing, 1998.

5. G. Davidson, *Group Theory for Chemists*, 1st Edition, Macmillan, 1991.

6. R.L. Flurry, *Symmetry Groups: Theory and Chemical Applications*, 1st Edition, Prentice-Hall, 1980.

7. A.M. Lesk, *Introduction to Symmetry and Group Theory for Chemists*, 1st Edition,

Kluwer Academic Publishers, 2004.

8. D.M. Bishop, *Group Theory and Chemistry*, 1st Edition, Dover Publications, 1993.

9. B.S. Tsukerblat, *Group Theory in Chemistry and Spectroscopy: A Simple Guide to Advanced Usage*, 1st Edition, Dover Publications, 2006.

10. D.C. Harris and M.D. Bertolucci, *Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy*, 1st Edition, Dover Publications, 1989.

11. K.V. Reddy, *Symmetry and Spectroscopy of Molecules*, New Age Science, 2nd Edition, 2009.

12. G. Raj, A. Bhagi and V. Jain, *Group theory and Symmetry in Chemistry*, 3rd Edition, Krishna Prakashan, 2010.

13. S.K. Dogra and H.S. Randhawa, *Symmetry and Groups Theory in Chemistry*, 1st Edition, New Age International, 2014.

14. P.K. Bhattacharya, *Group Theory and Its Chemical Applications*, 2ed Edition, Himalaya Publishing House, 2014.

15. K.C. Molloy, *Group Theory for Chemists: Fundamental Theory and Applications*, 2nd Edition, Woodhead Publishing, 2013.

16. M.C. Day and J. Selbin, *Theoretical Inorganic Chemistry*, 2nd Edition, Reinhold Book, 1969.

17. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Edition, Tata McGraw Hill Education, 2009.

18. R.K. Prasad, *Quantum Chemistry*, 4th Edition, New Age Science, 2009.

19. I.N. Levine, *Quantum Chemistry*, 6th Edition, Prentice Hall, 2008.

20. P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics*, 5th Edition, Oxford University Press, 2010.

21. D.A. McQuarrie, *Quantum Chemistry*, 2nd Revised Edition, University Science Books, 2007.

Code: **CH-412** Subject: **COORDINATION CHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- To be able to use Crystal Field Theory to understand the magnetic properties (and in simple terms the colour) of coordination compounds.
- To be able to describe the stability of metal complexes by the use of formation constants and to calculate thermodynamic parameters from them.
- Explain how complex reactions can be understood from the points of thermodynamics and kinetics.
- To become familiar with some applications of coordination compounds.

Course Outcome:

- Understand how stability of complex compounds can be determined.
- Establish reaction mechanism of selected complex compound.
- Explain how physical methods can be used to investigate the structure of complexes.
- To prepare complex compounds of select transition metals.
- Determine the magnetic properties metal complexes.
- Understand the mechanism of complex reactions.
- Determine the structure of some complex compounds.

Module-I: (10 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 Stabilisation Energy (CFSE) in Weak Field and Strong Field Cases, Factors Affecting Magnitude of 10Dq, Spectrochemical Series, Jahn-Teller Effect, Applications of Crystal Field Theory (Colour and Magnetic Properties of Complexes), Limitations of Crystal Field Theory.

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

Module-II: (10 Hours)

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

Module-III: (10 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.

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-IV: (10 Hours)

Reaction Mechanism of Transition Metal Complexes: Energy Profile of a Reaction, Reactivity of Metal Complexes, Inert and Labile Complexes, Kinetic Application of Valence Bond and Crystal Field Theories, Kinetics of Octahedral Substitution. Acid Hydrolysis, Factors Affecting Acid Hydrolysis, Base Hydrolysis, Conjugate Base Mechanism, Direct and Indirect Evidences in Favour 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.

Prescribed Books:

1. W.U. Malik, G.D. Tuli, and R.D. Madan, *Selected Topics in Inorganic Chemistry*, 17th Edition, S. Chand & 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 & 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 & Sons, 2008.

10. G.A. Lawrance, *Introduction to Coordination Chemistry*, 1st Edition, John Wiley & Sons, 2010.

Referred Books:

1. V. Balzani and V. Carasitti, *Photochemistry of Coordination Compounds*, 1st Edition, Academic Press, 1970.

2. B. Douglas, D.H. McDaniel, and J.J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, 1994.

3. M. Gerloch and E.C. Constable, *Transition Metal Chemistry: The Valence Shell in d-Block Chemistry*, 1st Edition, VCH Publications, 1994.

4. R.G. Wilkins, *Kinetics and Mechanisms of Reactions of Transition Metal Complexes*, 2nd Edition, VCH Publications, 1991.

5. M.L. Tobe and J. Burgess, *Inorganic Reaction Mechanisms*, Longman, 1999.

6. R.B. Jordan, *Reaction Mechanisms of Inorganic and Organometallic Systems*, 2nd Edition, Oxford University Press, 1991.

7. G. Wulfsberg, *Inorganic Chemistry*, University Science Books, 2000.

8. R.K. Sharma, *Text Book of Coordination Chemistry*, 1st Edition, Discovery Publishing, 2007.

9. R. Gopalan and V. Ramalingam, *Concise Coordination Chemistry*, 1st Edition, Vikas Publishing, 2009.

Code: **CH-413** Subject: **STRUCTURE AND REACTIVITY** Credits: **4 [4-0-0]**

Course Objective:

- To learn the basic principles that govern the structure of molecules.
- To provide a basic knowledge of aromatic concept and a fundamental knowledge of

organic reaction mechanisms.

Course Outcome:

- Apply fundamental concepts in chemical structure and bonding, including functional groups, to the rationalization of reactions of organic molecules.
- Apply the concepts of electron pushing to the fundamental organic reaction mechanisms.
- Apply logical thinking to evaluate, analyse and use information from different sources.

Module-I: (10 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. Bonds Weaker than Covalent (Addition compounds), Crown Ether Complexes and Cryptands, Inclusion Compounds, Cyclodextrins, Catenanes and Rotaxanes.

Module-II: (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-III: (10 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-IV: (10 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.

Prescribed Books:

1. J. March, *Advanced organic chemistry: Reactions, Mechanisms, and Structure*, 4th Edition, John Wiley & 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.

Code: **CH-414** Subject: **THERMODYNAMICS & CHEMICAL DYNAMICS** Credits: **4 [4-0-0]**

Course Objective:

- Basic definitions and terminology.
- Special definitions from the thermodynamics point of view.
- Why and how natural processes occur only in one direction unaided.
- Explain concept of property and how it defines state.
- How change of state results in a process, why processes are required to build
- Differences between work producing and work consuming cycles.
- How the concept of entropy forms the basis of explaining how well things are done, how to gauge the quality of energy.

Course Outcome:

- Understand and correctly use thermodynamic terminology.
- Define the concepts of heat, work, and energy.
- Explain fundamental thermodynamic properties.

- Develop the General Energy Equation.
- Derive and discuss the first law of thermodynamics.
- Understand the properties and relationships of thermodynamic fluids.
- Analyse basic thermodynamic cycles.
- Develop and discuss the second law of thermodynamics.

Module-I: (10 Hours)

Classical Thermodynamics: Brief Resume of the Concepts of Laws of Thermodynamics, Free Energy, 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: (10 Hours)

Statistical Thermodynamics: Concept of Distribution, Thermodynamic Probability and Most Probable Distribution. Ensemble Averaging, Postulates of Ensemble Averaging, Canonical, Grand Canonical and Micro-canonical Ensembles, Corresponding Distribution Laws (Using Lagrange's Method of Undetermined Multipliers), Partition Functions (Translational, Rotational, vibrational and Electronic Partition Functions), Calculation of Thermodynamic Properties in Terms of Partition Function. Applications of Partition Functions. Heat Capacity Behaviour of Solids, Chemical equilibria and Equilibrium Constant in Terms of Partition Functions, Fermi-Dirac Statistics, Distribution Law and Application to Metal. Bose-Einstein Statistics, Distribution Law and Application to Helium.

Module-III: (10 Hours)

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

Module-IV: (10 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, Salt Effect, Steady-State Kinetics, Kinetic and Thermodynamic Concept of Reactions, Dynamic Chain Reactions (H_2+Br_2 Reaction, Pyrolysis of CH_3CHO, and Decomposition of Ethane).

Fast Reactions: General Feature of Fast Reactions, Study of Fast Reactions by Relaxation, Stopped Flow, Flash Photolysis and NMR Techniques.

Prescribed Books:

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 & 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, A*n 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. J.O. Bockris and A.K.N. Reddy, *Modern Electrochemistry 1: Ionics*, 2nd Edition, Springer

13. A.A. Frost and R.G. Pearson, *Kinetics and Mechanism*, 2nd Edition, John Wiley and Sons, 1961.

14. K.J. Laidler, *Chemical Kinetics*, 3rd Edition, Pearson Education, 2008.

Referred Books:

1. A. Bahl, B.S. Bahl, and G.D. Tuli, *Essential of Physical Chemistry*, 19th Edition, S. Chand & Sons, 2012.

2. J. Goodisman, *Electrochemistry: Theoretical Foundations - Quantum and Statistical Mechanics, Thermodynamics, the Solid State*, 1st Edition, John Wiley and Sons, 1987.

3. P.L. Houston, *Chemical Kinetics and Reaction Dynamics*, 1st Edition, Dover Publications, 2006.

4. J.I. Steinfeld, J.S. Francisco, and W.L. Hase, *Chemical Kinetics and Dynamics*, 2nd Edition, Prentice Hall, 1999.

5. M.J. Pilling and P.W. Seakins, *Reaction Kinetics*, 2nd Edition, Oxford University Press, 1996.

6. R.J. Gale, *Spectroelectrochemistry: Theory and Practice*, Plenum Press, 1988.

7. P.C. Hiemenz and R. Rajagopalan, *Principles of Colloids and Surface Chemistry*, 3rd Edition, Marcel Dekker, 1997.

8. A.W. Adamson and A.P. Gast, *Physical Chemistry of Surfaces*, 6th Edition, John Wiley & Sons, 1997.

Code: **CH-415** Subject: **POLYMER CHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- The study of polymer chemistry in Master Course (MSc) is to provide a technology-based polymer engineering education. Find your springboard into a future-oriented field of global importance. Which other engineering material has such rich innovative properties.
- To be well prepared for a future in plastics technology you need a good basic knowledge of: Polymer Physics and Rheology, Polymer Materials, Polymer Design , Mould Design, Polymer Processing, Polymer Testing.
- A student with a Master of Science you will be an expert in polymer engineering and in demand as a member of staff in industry or scientific research (PhD).

Course Outcome:

- Polymer Chemistry is a course that introduces students to Polymer science, engineering and technology, where types of polymer, reactions to form polymer, polymerization mechanisms, structures, properties and application of polymer will be taught.
- Provides students with an opportunity to identify different types of polymers in our surrounding, introduces students to the practical application of polymers.
- Differentiate between natural and man-made polymers, explaining polymerization methods; understand polymerization kinetics and uses of polymers.
- The students will be made to recognise different polymeric materials commonly seen in our environment and their applications.
- Differences between natural and artificial polymers will be made clear to the students.
- The students would be taught chain and step growth polymerization mechanisms for addition and condensation polymer respectively.
- Students will be introduced to kinetic models.
- Fibre forming polymers and biopolymers will be taught.
- Homogeneous and heterogeneous polymerization process shall be discussed with the classes.

Module-I: (10 Hours)

Step Polymerisation: Mechanism of Step Polymerisation, Kinetics of Step Polymerisation, Molecular Weight Control in Linear Polymerisation, Molecular Weight Distribution in Linear Polymerisation, Polyfunctional Step Reaction Polymerisation, Newer Types of Step Polymerisation.

Radical Chain Polymerisation: Nature of Radical Chain Polymerisation, Rate of Radical Chain Polymerisation, Initiation, Molecular Weight, Chain Transfer, Inhibition and Retardation, Determination of Absolute Rate Constants, Energetic Characteristics, Auto Acceleration.

Module-II: (10 Hours)

Emulsion Polymerisation: Qualitative Picture, Quantitative Aspects, and Other Characteristics of Emulsion Polymerisation.

Ionic Chain Polymerisation: Comparison of Radical and Ionic Polymerisations, Kinetics, Cationic Polymerisation of the Carbon–Carbon Double Bond, Anionic Polymerisation of the Carbon–Carbon double Bond, Block Copolymers.

Module-III: (10 Hours)

Chain Copolymerisation: Copolymer Composition, Radical Copolymerisation, Ionic Copolymerisation, Kinetics of Copolymerisation, Applications of Copolymerisation.

Ring Opening Polymerisation: General Characteristics, Cyclic Ethers, Cyclic Amides.

Stereochemistry of Polymerisation: Types of Stereo Isomerism in Polymers, Properties of Stereo Regular Polymers, Forces of Stereoregulations in Alkene Polymerisation, Ziegler-Natta Polymerisation of Non-linear Vinyl Polymers, Kinetics

Module-IV: (10 Hours)

Polymer Structure and Physical Properties: Crystalline Melting Point, Glass Transition, Properties Involving Large Deformations, Properties Involving Small Deformations, Property Requirements and Polymer Utilizations.

Mechanical Behaviour of Polymers: An Energy Balance for Deformation and Fracture, Deformation and Fracture in Polymers, Crack Growth, Cyclic Deformations, Molecular Aspects of Fracture and Healing in Polymers, Behaviour of Adhesives. Conducting Polymers: General Characteristics with Examples, Polymer Molecular Weight, Different Types and Their Determination.

Prescribed Books:

1. F.W. Billmeyer Jr., *Textbook of Polymer Science*, 3rd Edition, John Wiley & Sons, 2008.

2. R.J. Young and P.A. Lovell, *Introduction to Polymers*, 3rd Edition, CRC Press, 2011.

3. H.R. Allcock and F.W. Lampe, *Contemporary Polymer Chemistry*, 2nd Edition, Prentice Hall, 1990.

4. G. Odian, *Principles of Polymerisation*, 4th Edition, John Wiley & Sons, 2004.

5. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th Edition, John Wiley & Sons, 2006.

Referred Books:

1. M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Edition, Oxford University Press, 2009.

2. C.E. Carraher Jr., *Introduction to Polymer Chemistry*, 3rd Edition, CRC Press, 2013.

3. P.J. Flory, *Principles of Polymer Chemistry*, 16th Edition, Cornell University Press, 1995.

4. A. Ravve, *Principles of Polymer Chemistry*, 1st Edition, Springer, 1995.

5. P.C. Hiemenz and T.P. Lodge, *Polymer Chemistry*, 2nd Edition, CRC Press, 2007.

6. D.J. Walton and J.P. Lorimer, *Polymers*, 1st Edition, Oxford University Press, 2013.

Code: **CH-416** Subject: **INORGANIC GENERAL PRACTICAL** Credits: **2 [0-0-3]**

Course Objective:

- Qualitative analysis of inorganic salts mixture containing different acid and basic radicals in addition to insoluble mixture will be performed.

Course Outcome:

- Identify different acid and basic radicals present in mixture of inorganic salts.
- Identification of insoluble compounds.
- Identification of different interfering radicals.
- Analysis of transition metals such as Tungstate, Vanadate, Molybdate and Cerium(IV) present in a supplied mixture.

Qualitative Analysis: Analysis of An Inorganic Mixture Containing not More Than 6 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.

Prescribed Books:

1. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Pearson Education, 2009.

Code: **CH-417** Subject: **ORGANIC GENERAL PRACTICAL** Credits: **2 [0-0-3]**

Course Objective:

- Qualitative analysis of unknown organic compounds along with their purification will be performed.

Course Outcome:

- Identification of organic functional groups.
- Separation of organic compounds in a binary mixture using different chromatographic techniques.
- Purification of organic compounds.

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

Referred Books:

1. D.J. Pasto, C.R. Johnson, and M.J. Miller, *Experiments and Techniques in Organic Chemistry*, 1st Edition, Prentice Hall, 1991.

2. H. Middleton, *Systematic Qualitative Organic Analysis*, 1st Edition, Edward Arnold, 1939.

3. H.T. Clarke, *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Edition, Edward Arnold, 1931.

4. A.I. Vogel, A.R. Tatchell, B.S. Furniss, A.J. Hannaford, and P.W.G. Smith, *Vogel's Textbook of Practical Organic Chemistry*, 5th Edition, Pearson Education, 1996.

5. K.L. Williamson and K.M. Masters, *Macroscale and Microscale Organic Experiments*, 6th Edition, Cengage Learning, 2010.

6. V.K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, 1st Edition, Universities Press, 2000.

SEMESTER: 8th

Code: **CH-421** Subject: **ANALYTICAL CHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- The course discusses the general theories behind the use of each instrument as well analysis of experimental data.
- This course begins with a review of general chemistry and an introduction to analytical terminology.

- Students will learn terms relevant to the process of measuring chemical compounds, such as sensitivity and detection limit.
- The course continues with a unit on common spectrochemical methods, followed by an extension of these methods in a unit on atomic spectroscopy.
- These methods allow the qualitative and quantitative analysis of compounds of interest. Students will also learn about chromatography, which is the science behind purifying samples.
- Separations of complex mixtures are achieved through a variety of chromatographic techniques.
- The course concludes with a section on electrochemical methods, examining the interaction between the electrolyte and current of potential during chemical reactions.

Course Outcome:

- Demonstrate a mastery of various methods of expressing concentration.
- Use a linear calibration curve to calculate concentration.
- Describe the various spectrochemical techniques as described within the course.
- Use sample data obtained from spectrochemical techniques to calculate unknown. concentrations or obtain structural information where applicable.
- Describe the various chromatographies described within this course and analyze a given chromatogram.
- Demonstrate an understanding of electrochemistry and the methods used to study the response of an electrolyte through current of potential.

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: (10 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: (10 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: (10 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.

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).

Prescribed Books:

1. Principles of Instrumental Analysis, by D.A. Skoog, F.J. Holler and T.A. Nieman, 5th Ed., Saunders College publishing 1998.

2. D.A. Skoog, F.J. Holler, and S.R. Crouch, *Principles of Instrumental Analysis*, 6th Edition, Thomson Brooks/Cole, 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 & II*, Ellis Horwood, 1989.

6. D.A. Skoog, D.M. West, F.J. Holler, and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edition, Cengage Learning, 2014.

7. J. Wang, *Analytical Electrochemistry*, 3rd Edition, John Wiley and Sons, 2006.

Referred Books:

1. R.M. Smith, *Supercritical Fluid Chromatography*, Royal Society of Chemistry, 1988.

2. D.L. Andrews, *Perspectives in Modern Chemical Spectroscopy*, Springer-Verlag, 1990.

3. G.D. Christian, P.K. Dasgupta, and K.A. Schug, *Analytical Chemistry*, 7th Edition, Wiley & Sons, 2013.

4. R.A. Day and A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall, 1991.

5. J. Mendham, R.C. Denney, J. D. Barnes, and M.J.K. Thomas, *Vogel's Quantitative Chemical Analysis*, 6th Edition, Prentice Hall, 2000.

Code: **CH-422** Subject: **STEREOCHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- To provide knowledge on Stereochemistry, it is the branch of chemistry concerned with the three-dimensional arrangement of atoms and molecules and the effect of this on chemical reactions.

Course Outcome:

- Fundamentals which are required to understand stereochemistry such as Chirality, Fischer projection and R and S notations, threo and erythro nomenclature, E and Z nomenclature, Optical isomerism in biphenyls and allenes.
- Concept of Prostereoisomerism and Assymetric synthesis (including enzymatic and catalytic nexus), Conformation of a few acyclic molecules (alkanes, haloalkanes), Conformation of cyclic systems having one and two sp^2 carbon atoms.
- Knowledge on Molecular dissymmetry and chiroptical properties, linearly and circularly polarised lights, circular birefringence and circular dicroism, ORD, Plane curves, Cotton

effect.

Module-I: (10 Hours)

Chirality, Fischer Projection and R and S Notations, Threo and Erythro Nomenclature, E and Z Nomenclature, Optical Isomerism in Biphenyls and Allenes, Concept of Prostereoisomerism and Assymetric Synthesis (Including Enzymatic and Catalytic Nexus), Conformation of Acyclic Molecules (Alkanes, Haloalkanes), Conformation of Cyclic Systems Having One and Two sp^2 Carbon Atoms.

Module-II: (10 Hours)

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

Module-III: (10 Hours)

Molecular Dissymmetry and Chiroptical Properties, Linearly and Circularly Polarised Lights, Circular Birefringence and Circular Dichroism, ORD, Plane Curves, Cotton Effect, Rotatory Dispersion of Ketones, the Axial Haloketone Rule, the Octane Rule. Helicity Rule, Lowe's Rule, Empirical Rule Involving the Benzene Chromophore.

Prescribed Books:

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.

Code: **CH-423** Subject: **SPECTROSCOPY-I** Credits: **4 [4-0-0]**

Course Objective:

- The objective of the subject is to provide the knowledge of spectroscopy with emphasis on electronic, rotation, vibration, Raman spectroscopy, Mossbauer spectroscopy and their applications.

Course Outcome:

- How light interacts with matter and electromagnetic spectrum.
- Microwave, Infrared, Rotational-Vibrational Spectra and their applications for chemical analysis.
- Qualitative description about principle of Raman spectroscopy and its application in chemical analysis.
- Electronic spectroscopy of different elements and simple molecules.
- Mossbauer spectroscopy and its application.

Module-I: (10 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: (10 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: (10 Hours)

Raman Spectroscopy: Theory of Raman Spectra, Rotational Raman Spectra, Vibrational

Raman Spectra, Rotational-Vibrational Raman Spectra, comparison with IR spectra.

Module-IV: (10 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.

Prescribed Books:

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 & Sons, 2004.

3. H. Windawi and F.F.L. Ho, *Applied Electron Spectroscopy for Chemical Analysis*, John Wiley & Sons, 1982.

4. R.V. Parish. *NMR, NQR, EPR and Mössbauer Spectroscopy in Inorganic Chemistry*, Ellis Horwood, 1990.

5. R.S. Drago, *Physical Methods for Chemists*, 2nd Edition, Saunders College Publishing, 1992.

6. G.M. Barrow, *Introduction to Molecular Spectroscopy*, 1st Edition, McGraw Hill, 1962.

7. R. Chang, *Basic Principles of Spectroscopy*, 1st Edition, McGraw Hill, 1971.

8. H.H. Jaffe and M. Orchin, *Theory and Applications of Ultraviolet Spectroscopy*, 1st Edition, John Wiley & Sons, 1966.

9. P. K. Ghosh: *Introduction to Photoelectron Spectroscopy*, John Wiley & Sons, 1983.

10. A. Carrington and A.D. McLachlan, *Introduction to Magnetic Resonance*, 1st Edition, Harper & Row, 1967.

Code: **CH-424** Subject: **ORGANIC REACTION MECHANISM** Credits: **4 [4-0-0]**

Course Objective:

- To provide an understanding of Organic reaction mechanisms for future studies in

chemistry and allied subjects.

- To provide students with the tools to describe and work out reaction mechanisms using the 'curly arrow' notation.

Course Outcome:

- Design experiments to probe mechanisms.
- Combine reactions to achieve simple synthesis of target molecules.

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.

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.

Module-II: (10 Hours)

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.

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-III: (10 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-IV: (10 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.

Prescribed Books:

1. J. March, *Advanced organic chemistry: Reactions, Mechanisms, and Structure*, 4th Edition, John Wiley & 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.

Code: **CH-425** Subject: **SURFACE CHEMISTRY AND NUCLEAR CHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- The course deals with important principles and phenomena related to colloid systems and

nuclear systems.

- These subjects are fundamental to the understanding and design of a range of processes like e.g. adhesion, lubrication, cleaning, oil recovery, water and air purification, nuclear processes.
- Furthermore, the subjects are essential for the application and design of a number of chemical products like e.g. paint, glue, detergents, cosmetics, drugs and foods.
- Finally, the course offers understanding of several naturally occurring phenomena like e.g. fog, rain drops, the capillary effect, the red sunset, the blue sky, the rainbow, nuclear fission fusion processes, radioactive nature of substances.

Course Outcome:

- Evaluate and describe colloidal nano-technological and chemical systems, processes and products.
- Use different theories to calculate surface and interfaces tensions and use this to estimate e.g. wetting and other system characteristics.
- Identify mechanisms for adhesion between surfaces and materials and use different methods to estimate this.
- Describe the most important and fundamental theories in surface chemistry.
- Explain micellation of surfactants, know how to measure this and calculate dependencies of salt concentration, system temperature and surfactant chain length.
- Compare and understand adsorption in gas-liquid and solid-liquid surfaces and perform quantitative adsorption calculations.
- Calculate molar mass and molecular shape of colloid particles and polymers based on experimental data.
- Describe the interactions between colloidal particles and identify similarities and differences for the governing molecular forces and interactions.
- Explain the most important parameters for the theories of colloidal interaction and perform calculations using the theories.
- Describe the conditions for stability of colloidal systems and discuss and compare

different mechanisms for stabilization.

- Describe mechanisms for stabilization of emulsions and foam, and design emulsions and foam by using various semi-empirical methods.
- Calculate mass differences and binding energies for nuclei and nuclear reactions; use this information to identify species that can undergo fusion or fission.
- Calculate kinetic parameters for nuclear decay including applications to radioactive dating.
- Balance nuclear reactions identifying which nuclear particles are involved in the process and use the neutron to proton ratio to predict the possible types of nuclear decay an isotope could undergo.

Module-I: (10 Hours)

Phase Rule and Catalysis: Derivation of Phase Rule, Brief Concept on One and Two Component System, Application of Phase Rule to Three Component Systems of Both Solids and Liquids.

Kinetics of Catalytic Reactions: Acid-Base Catalysis, Enzyme Catalysis, Heterogeneous Catalysis.

Module-II: (10 Hours)

Adsorption: Surface Tension, Capillary Action, Adsorption, Types of Adsorption, Gibbs Adsorption Isotherm, Freundlich's Adsorption Isotherm, Langmuir's Adsorption Isotherm and Its Limitations, BET Adsorption Isotherm and Its Applications, Heat of Adsorption, Estimation of Surface Areas of Solids from Solution Adsorption Studies.

Module-III: (10 Hours)

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

Module-IV: (10 Hours)

Nuclear Chemistry: Classification of Nuclides, Nuclear Stability, Binding Energy and Nuclear Models. Characteristics of Radioactive Decay, Decay Kinetics, Parent-Daughter

Decay Growth Relationships, Detection and Measurement of Radioactivity, Advances in the Solid and Liquid Scintillation Counting Techniques, Methods for the Determination of Half Life Period of Single and Mixed Radionuclides. Nuclear Fission, Nuclear Fuels and Nuclear Reactors, Nuclear Fuel Reprocessing, Fast Breeder Reactors, Radiological Safety Aspects and Radioactive Waste Managements. Interaction of Radiation with Matter, Effect of Ionizing/Non-ionizing Radiations on Water, Aqueous Solutions and Organic Compounds, Radiation Dosimetry. Preparation and Separation of Radioactive Isotopes, Application of Radioisotopes and Radiations in Various Fields, Isotopic Dilution Techniques, Neutron Activation Analysis and Its Applications.

Prescribed Books:

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 & Sons, 2001.

3. A. Bahl, B.S. Bahl, and G.D. Tuli, *Essential of Physical Chemistry*, 19th Edition, S. Chand & Sons, 2012.

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. G. Friedlander, J.W. Kennedy, E.S. Macias, and J.M. Miller, *Nuclear and Radiochemistry*, 3rd Edition, John Wiley & Sons, 1981.

7. B.G. Harvey, *Introduction to Nuclear Physics & Chemistry*, Prentice Hall, 1969.

8. R.T. Overman, *Basic concept of Nuclear Chemistry*, Chapman & Hall, 1965.

9. N. Nesmeyanov, *Radiochemistry*, Mir Publication, 1974.

10. J.W.T. Spinks and R.J. Woods, *An Introduction to Radiation Chemistry*, 3rd Edition, John Wiley & Sons, 1990.

11. H.J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edition, New Age International, 1995.

12. G. Choppin, J.-O. Liljenzin, J. Rydberg, and C. Ekberg, *Radiochemistry and Nuclear Chemistry*, 4th Edition, Elsevier, 2013.

13. W.D. Loveland, D.J. Morrissey, and G.T. Seaborg, *Modern Nuclear Chemistry*, 1st Edition, John Wiley & Sons, 2006.

Code: **CH-426** Subject: **PHYSICAL GENERAL PRACTICAL** Credits: **2 [0-0-3]**

(Any Six from the Following)

Course Objective:

- To perform Conductometric, Potentiometric and spectrometric experiments for the analysis of different chemical reactions.

Course Outcome:

- Conductometric titration of a mixture of acid and bases of different strengths.
- Potentiometric titration of a mixture of acids and bases of different strengths.
- Determination of unknown concentration of a solution spectro-photometrically.
- Determination of rate constant of hydrolysis of ester titrometrically.
- Study of complex formation.
- Study of inversion of cane sugar in acid medium by polarimetry.

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 HCl + CH_3COOH with NaOH.

4. Determination of Solubility Product of $BaSO_4$.

5. Potentiometric Titration of Strong Acid with Strong Base.

6. Verification of Beer's Lambert Law and Unknown Concentration Determination.

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 Titrometrically.

10. To Study the Complex Formation Between Ammonia and Cu^{+2}.

11. To Study of an Equilibrium KI + I_2 = KI_3.

12. To Study the Simultaneous Equilibria in Benzoic Acid-benzene Water System.

13. Determination of Unknown Dextrose Solution by Polarimetry.

14. Study of Inversion of Cane Sugar in Acid Medium by Polarimetry.

Prescribed Books:

1. R.C. Das and B. Behera, *Experimental Physical Chemistry*, 1st Edition, Tata McGraw-Hill, 1984.

2. P.S. Sindhu, *Practical's in Physical Chemistry: A Modern Approach*, 1st Edition, Macmillan, 2006.

Code: **CH-427** Subject: **ANALYTICAL CHEMISTRY PRACTICAL** Credits: **2 [0-0-3]**

Course Objective:

- To perform quantitative analysis of Ores/alloys along with the determination of complex composition and separation of different metal ions using ion-exchange method.

Course Outcome:

- Determination of complex composition and stability constant of a complex by Job's method spectro-photometrically
- Determination of total cation concentration and separation of different metal ions using cation exchange resin.
- Quantitative analysis of cement/dolomite/brass.
- Determination of half-cell potential of Cd(II) ion in KCl solution and estimation of Cd(II) ion in unknown solution by polarography.

Spectrophotometry:

1. Determination of Composition of a Complex by Job's Method.

2. Determination of Stability Constant of a Complex.

Ion Exchange Methods:

1. Determination of Total Cation Concentration in a Given Sample of Water.

2. Separation of Ni(II) & Co(II) in Cation Exchange Column Using Citrate buffer as a

Chelating Agent.

Polarography:

1. Determination of Half Wave Potential of Cd(II) Ion in KCl Solution and Estimation of Cd Ion in Unknown Solution Containing 0.1M KCl.

Quantitative Analysis of Ores and Alloys:

1. Analysis of Cement/Dolomite/Brass.

Prescribed Books:

1. R.C. Das and B. Behera, *Experimental Physical Chemistry*, 1st Edition, Tata McGraw-Hill, 1984.

2. O.P. Vermani and A.K. Narula, *Applied Chemistry: Theory and Practice*, 2nd Edition, New Age International, 2005.

3. P.K. Kar, S. Dash, and B. Mishra, *B. Tech. Practical Chemistry*, 1st Edition, Kalyani Publishers, 2005.

SEMESTER: 9th

Code: **CH-511** Subject: **ORGANOMETALLICS** Credits: **4 [4-0-0]**

Course Objective:

- Introduction to transition metal-mediated organic chemistry.
- Organometallic mechanisms will be discussed in the context of homogeneous catalytic systems currently being used in organic synthesis (e.g. cross coupling, olefin metathesis, asymmetric hydrogenation, etc.).
- Emphasis will be placed on developing an understanding of the properties of transition metal complexes and their interactions with organic substrates that promote chemical transformations.

Couse Outcome:

- Have a good overview of the fundamental principles of organo-transition-metal chemistry and know how metals and ligands affect chemical properties.
- Be able to use knowledge about structure and bonding issues to understand the stability

and reactivity of simple organometallic complexes.

- Have insight into the use of modern methods to characterize organometallic compounds.
- Understand fundamental reaction types and mechanisms, and how to combine these to understand efficient catalytic processes.
- Know important applications of organometallic homogeneous catalysis in the production of large-scale (bulk) and smaller-scale (fine chemicals) production.

Module-I: (10 Hours)

Compounds of Transition Metal Carbon Multiple Bonds (Alkylidines, Alkylidynes, Low Valent Carbenes and Carbines- Synthesis Nature Bond Structural Characteristics, Nucleophilic and Electrophilc Reactions on the Ligands Role in Organic Synthesis

Module-II: (10 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: (10 Hours)

Transition Metal Pi Complexes with Unsaturated Organic Molecules (Dienyl, Arene and Trienyl Complexes) Preparation, Properties, Nature of Bonding and Structural Features. Important Reactions Relating to Nucleophilic and Electrophilic Attack on Ligands and to Organic Synthesis.

Module-IV: (10 Hours)

Organometallic compounds and homogeneous catalytic reactions: Coordinating Unsaturation, Acid Base Behaviour of Metal Complexes, Oxidative Addition Reaction, Stereochemistry and Mechanism of Addition, Insertion Reactions, Intra Molecular Hydrogen Transfer, Isomerization, Hydrogenation of Alkenes, Hydroformylation, Zigler-Natta Polymerization, Alkene Metathesis.

Prescribed Books:

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 & Sons, 2014.

3. A.J. Pearson, *Metallo-Organic Chemistry*, 1st Edition, John Wiley & 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.

Code: **CH-512** Subject: **PHOTOCHEMISTRY & PERICYCLIC REACTION** Credits: **4 [4-0-0]**

Course Objective:

- The course will involve a discussion of molecular organic photochemistry and pericyclic reactions.
- Fundamental principles of photochemistry including photochemical reactions and pericyclic reactions along with their applications will be discussed.

Course Outcome:

- Understand detailed mechanism about first order photochemical processes including luminescence such as Fluorescence and phosphorescence.
- Understand detailed mechanistic investigations of photochemical reactions such as dissociation, reduction, cycloaddition etc.
- Understand different pericyclic reactions and their application in organic synthesis.

Module-I: (10 Hours)

First Order Photochemical Processes: Light Absorption, Fluorescence and Phosphorescence.

Photo Reactions: Dissociation, Reduction, Isomerisation, Cycloaddition, Paterno-Buchi Reaction, Norrish type I and II Reactions, Di-Pi-Methane Reaction, Photochemistry of

Arenes.

Module-II: (10 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 and Aromatic Transition State Concept. ***Electrocyclic Reactions:*** Con- and Dis-rotatory Motions, 4n, 4n+2 and Allyl Systems. ***Cycloaddition Reactions:*** Supra- and Antara-facial Additions, 4n and 4n+2 Systems, 2+2 Additions of Ketenes, 1,3 Dipolar Cycloadditions and Cheletropic Reactions.

Module-III: (10 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: (10 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).

Prescribed Books:

1. J. Singh and J. Singh, *Photochemistry and Pericyclic Reaction*, 3rd Edition, New Age International, 2009.

2. C.E. Wayne and R.P. Wayne, *Photochemistry*, 1st Edition Oxford University Press, 1996.

3. S. Sankararaman, *Pericyclic reactions - A Textbook: Reactions, Applications and Theory*, 1st Edition, John wiley & sons, 2005.

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

5. G.B. Gill and M.R. Wills, *Pericyclic Reactions*, 1st Edition, Springer, 1974.

6. S. Kumar, V. Kumar, and S.P. Singh, *Pericyclic Reactions: A Mechanistic and Problem-Solving Approach*, 1st Edition, Elsevier, 2016.

7. R.B. Woodward and R. Hoffmann, *The Conservation of Orbital Symmetry*, 2nd Edition,

Verlag Chemie/Academic Press, 1970.

8. T.L. Gilchrist and R.C. Storr, *Organic Reactions and Orbital Symmetry*, 2nd Edition, Cambridge University Press, 1979.

9. T.H. Lowry and K.S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3rd Edition, Harper & Row, 1987.

10. J.D. Roberts and M.C. Caserio, *Basic Principles of Organic Chemistry*, 1st Edition, W.A. Benjamin, 1965.

11. B.P. Mundy, M.G. Ellerd, and F.G. Favaloro Jr., *Name Reactions and Reagents in Organic Synthesis*, 2nd Edition, John Wiley & Sons, 2005.

12. M.B. Smith, *Fiesers' Reagents for Organic Synthesis: Collective Index for Volumes 1-22*, 1st Edition, John Wiley & Sons, 2005.

Code: **CH-513** Subject: **SPECTROSCOPY-II** Credits: **4 [4-0-0]**

Course Objective:

- To introduce the application of different spectroscopic techniques like ESR, UV, IR, NMR and Mass spectroscopy for analysis of organic compounds.

Course Outcome:

- Understand the basic principle, instrumentation and application of ESR, IR, NMR and Mass spectroscopy in the elucidation of structure of organic compounds.
- Deduce organic structures involving UV, IR, NMR and Mass Spectroscopy data.
- Analyse the spectra of different organic compounds.
- Study the spectra of compounds and propose structures for compounds.
- Study spectra of compounds, determine functional groups and write structures.

Module-I: (10 Hours)

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

IR Spectroscopy: Application in Elucidation of Structure of Organic Molecules.

Module-II: (10 Hours)

Nuclear Magnetic Resonance (NMR) Spectroscopy: General Introduction and Definition, Chemical Shift, Spin-Spin Interaction, 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, Complex Spin-Spin Interaction Between Two, Three, Four and Five Nuclei (First Order Spectra), Virtual Coupling, Stereochemistry, Hindered Rotation, Karplus Curve-Variation of Coupling Constant with Dihedral Angle, Simplification of Complex Spectra, Nuclear Magnetic Double Resonance, Contact Shift Reagents, Solvent Effects, Fourier Transform Technique, Nuclear Overhauser (NOE). Resonance of Other Nuclei.

Module-III: (10 Hours)

Carbon-13 NMR Spectroscopy: General Considerations, Chemical Shift (Aliphatic, Olefinic, Alkyne, Aromatic, Heteroaromatic and Carbonyl Carbon), Coupling Constants. Two Dimension NMR Spectroscopy – COSY, NOESY, DEPT, APT and Inadequate Techniques

Nuclear Quadrupole Resonance (NQR) Spectroscopy: Quadrupole Nuclei, Quadrupole Moments, Electric Field Gradient, Coupling Constant, Splitting, Applications.

Module-IV: (10 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).

Problems Involving UV, IR, NMR and Mass Spectroscopy.

Prescribed Books:

1. I.L. Finar, *Organic Chemistry, Volume II*, 6th Edition, Pearson Education, 2002.

2. R.M. Silverstein, F.X. Webster, D.J. Kiemle, and D.L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Edition, John Wiley & Sons, 2014.

3. A. Lund, S. Shimada, and M. Shiotani, Principles and Applications of ESR Spectroscopy, 1st Edition, Springer, 2011.

4. M. Balci, *Basic ^{1}H- and ^{13}C -NMR Spectroscopy*, 1st Edition, Elsevier, 2005.

5. J.W. Akitt and B.E. Mann, *NMR and Chemistry: An Introduction to Modern NMR Spectroscopy*, 4th Edition, Stanley Thornes, 2000.

6. R.V. Parish. *NMR, NQR, EPR and Mössbauer Spectroscopy in Inorganic Chemistry*, Ellis Horwood, 1990.

7. E. de Hoffmann and V. Stroobant, *Mass Spectrometry: Principles and Applications*, 3rd Edition, John Wiley & Sons, 2007.

Code: **CH-514** Subject: **ENVIRONMENTAL CHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- To prepared trend manpower in chemistry to serve the country in the field of science and technology, higher research in country.
- In addition, the manpower can work for the growth of nation in the field of pharmaceutical lab, Quality control lab, defence and other.

Course Outcome:

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

Module-I: (10 Hours)

Air Pollution: Air Pollutants, Air Quality Standards, Production, Fate, Effects and Control of Gaseous Pollutants, Oxides of Carbon, Nitrogen and Sulphur, Organic Air Pollutants, Photochemical Reactions, Photochemical Smog, Greenhouse Effect, Climate Change, Global warming, Acid Rain and Ozone Depletion.

Water Pollution: Water World, Source of Water**,** Water Quality, Water Pollutants (Inorganic and Organic), Sources, Fate, Effects and Controlling Measures, Chemical Speciation, Pollution by Radionuclides, Biochemical Oxygen Demand, Chemical Oxygen Demand, Eutrophication, Biodegradation of Pollutants.

Module-II: (10 Hours)

Water Treatment: Treatment of Water for Drinking, Electro-dialysis, Ion Exchange, Reverse Osmosis, Desalination Processes, Removal of Iron, Manganese, Phosphorous, Calcium and

Nitrogen and Treatment of Water for Industrial Purposes, Sedimentation, Coagulation, Flocculation, Filtration, Adsorption, Disinfection of Water, Sewage Treatment (Physical and Chemical Methods), Health Effects of Drinking Water Treatment Technologies, Impact of Detergents, Pesticides and Other Additives on Sewage Treatment.

Module-III: (10 Hours)

Oils in Fresh & Marine Water: Sources of Oil Pollution, Chemistry and Fate of Hydrocarbons Oil in Run Off and Ground Water, Biodegradation, Effect on Aquatic Organisms and Communities, Treatment and Disposal Technology.

Soil Pollution: Soil Pollutants (Inorganic, Organic, Pesticides, Radionuclides), Sources and Effects on Nature and Properties of Soil, Crops, Plants and Terrestrial Animals.

Module-IV: (10 Hours)

Hazardous Wastes: Nature and Sources of Hazardous Wastes, Classification, Characteristics and Constituents, Transport and Effects, Treatment by Physical and Chemical Methods, Thermal Treatment Methods, Biodegradation of Wastes, Disposal of Hazardous Wastes. Waste Management and Industrial by Products, Natural Hazards and Management, Control of Subsurface Migration of Hazardous Waste, Biomedical Waste Management, Environmental Management and Sustainable Development.

Prescribed Books:

1. S.E. Manahan, *Environmental Chemistry*, 9th Edition, CRC Press, 2010.

2. A.K. De, *Environmental Chemistry*, 2nd Edition, 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. Lippmann and R.B. Schlesinger, *Chemical Contamination in the Human Environment*, 1st Edition, Oxford University Press, 1979.

5. H.M. Dix, *Environmental Pollution: Atmosphere Land Water and Noise*, 1st Edition, John Wiley & Sons, 1981.

6. J.C. Crittenden, R.R. Trussell, D.W. Hand, K.J. Howe, G. Tchobanoglous, *MWH's Water Treatment: Principles and Design*, 3rd Edition, John Wiley & Sons, 2012.

7. R.M. Harrison, *Pollution: Causes, Effects and Control*, 5th Edition, Royal Society of

Chemistry, 2014.

8. C. Binnie, M. Kimber, and G. Smethurst, *Basic Water Treatment*, 3rd Edition, Thomas Telford, 2003.

9. G.W. Dawson and B.W. Mercer, *Hazardous Waste Management*, 1st edition, John Wiley & Sons, 1986.

10. M.D. LaGrega, P.L. Buckingham, and J.C. Evans, *Hazardous Waste Management*, 2nd Edition, Waveland Press, 2010.

Referred Books:

1. L.K. Wang, Y.-T. Hung, and N.K. Shammas *Handbook of Advanced Industrial and Hazardous Wastes Treatment*, 1st Edition, CRC Press, 2010.

2. J. Pichtel, Waste Management Practices: Municipal, Hazardous, and Industrial, 2nd Edition, CRC Press, 2014.

3. G. Woodside, *Hazardous Materials and Hazardous Waste Management*, 2nd Edition, John Wiley & Sons, 1999.

4. C. Ray and R. Jain, *Drinking Water Treatment: Focusing on Appropriate Technology and Sustainability*, 1st Edition, Springer, 2011.

5. 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.

6. 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.

Code: **CH-515** Subject: **SUPRAMOLECULAR CHEMISTRY** Credits: **4 [4-0-0]**

Course Objective:

- The objective of this interdisciplinary module is for students to learn the fundamental principles of molecular recognition and supramolecular chemistry.
- Any given molecule's supramolecular or non-covalent chemistry is what determines its function so a focused and coherent delivery of non-covalent chemistry will equip students with the ability to relate structure and function.

Course Outcome:

- Identify different types of non-covalent interactions.
- Discuss and interpret the thermodynamics of host-guest interactions.
- Discuss the molecular recognition properties of common receptors eg. crowns, calixarenes etc.
- Understand the principles of self-assembly and template directed syntheses of a broad range of complex molecular architectures.
- Understand and critically analyse 'Hot-topics' where the principles of supramolecular chemistry are applied to the design of functional architectures.

Module-I: (10 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: (10 Hours)

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

Module-III: (10 Hours)

Ionophores for Cations and Anions: Chelate, Macrocyclic and Cryptate Effects, Complexation Selectivity, Thermodynamics (Enthalpy, Entropy and Heat Capacity Changes), Macrocycles with Secondary Binding Sites, Effect of Solvent.

Crown Ethers*:* Synthesis of All Oxygen, All Nitrogen, and All Sulphur and Oxygen-Nitrogen Bridged Systems, 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, Breslow’s Remote Functionalization Using Substituted Benzophenones.

Module-IV: (10 Hours)

Bio-organic Chemistry of Phosphates*:* Biological Role of Phosphate Macromolecules, General Properties, Experimental Evidences for DNA Double Helix, Chemical Synthesis of Polynucleotides (Trinucleotide), Role of Other Nucleotide Phosphates (NADP, FAD, CAMP & CGMP)

Selected Applications: Synthetic Classification of Organic Electron Transfer Reactions, Marcus Theory, Photoinduced Intramolecular Electron Transfer Systems, Introduction to Molecular Switches, Optical Devices, Electrochemical Devices.

Prescribed Books:

1. H.-J. Schneider and A.K. Yatsimirsky, *Principles and Methods in Supramolecular Chemistry*, 1st Edition, John Wiley & Sons, 1999.

2. J.W. Steed and J.L. Atwood, *Supramolecular Chemistry*, 2nd Edition, John Wiley & 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 & 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 & Sons, 1991.

Code: **CH-516** Subject: **INDUSTRIAL PRACTICAL** Credits: **2 [0-0-3]**

Course Objective:

- To perform experiments which will be helpful when working in an industry.

Course Outcome:

- Determine residual chlorine and ammonia in sewage water.
- Determination of active chlorine in bleaching powder.

- Determination of flash point and viscosity of a lubricating oil.
- Determination of calorific value, carbon residue, volatile matter of a sample of coal.

1. Determination of Percentage of Purity of Commercially Available Different N, P and K Fertilizer.

2. Water Analysis: (a) Residual Chlorine in Town Supply Water (b) Ammonia Content of Sewage Water.

3. Determination of Acid Value, Saponification Value and Iodine Value of Different Oils.

4. Determination of Chlorine in Bleaching Powder.

5. Determination of Flash Point of a Lubricating Oil.

6. Determination of Viscosity of a Lubricating Oil.

7. Determination of Calorific Value, Carbon Residue, Volatile Matter of a Sample of Coal.

Prescribed Books:

1. B. Mishra, S. Dash, and P.K. Kar, *B.Tech. Practical Chemistry*, 1st Edition, Kalyani Publishers, 2005.

2. J.N. Gurtu and A. Gurtu, *Advanced Physical Chemistry Experiments*, 8th Edition, Pragati Prakashan, 2015.

Code: **CH-517** Subject: **ENVIRONMENTAL PRACTICAL** Credits: **2 [0-0-3]**

Course Objective:

- The course describes and gives hands on experience about different environmental related practical to the students

Course Outcome:

- Determination of alkalinity and dissolved oxygen, chlorine, iron content and nitrate in water sample.
- Determination of COD and hardness in a supplied water.
- Determination of phosphate and sulphate in sewage sample.

1. Determination of Alkalinity of Water.

2. Determination of Dissolved Oxygen in a Sample of Water.

3. Determination of Chemical Oxygen Demand.

4. Determination of Chloride Content in a Sample of Water.

5. Determination of Iron Content in a Sample of Water.

6. Determination Organic Carbon in Soil Sample.

7. Determination of Phosphate in Garden Soil.

8. Determination of Nitrate in Water Sample.

9. Estimation of Gaseous Pollutants (SO_x and NO_x) in Ambient Air.

10. Determination of Sulphate in Sewage Sample.

11. Determination of Total Hardness, Calcium Hardness and Magnesium Hardness.

Prescribed Books:

1. B. Mishra, S. Dash, and P.K. Kar, *B.Tech. Practical Chemistry*, 1st Edition, Kalyani Publishers, 2005.

2. O.P. Vermani and A.K. Narula, *Applied Chemistry: Theory and Practice*, 2nd Edition, New Age International, 2005.

SEMESTER: 10th

Code: **CH–521** Subject: **SOLID STATE AND NANOMATERIALS** Credits: **4 [4-0-0]**

Course Objective:

- To provide an introduction to the concepts underlying solid state chemistry and nanomaterials.
- An overview of the synthesis and applications of inorganic materials.
- Structure and compound identification in the solid state.
- Studies of the magnetism, electrical and optical properties of the solid state compounds and nanomaterials.

Course Outcome:

- 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.
- Give a qualitative and quantitative representation of crystal defects in crystalline solids and knowledge of defects related to non-stoichiometry in some important classes of inorganic materials.
- Give a qualitative representation of the relationship between structure/bonding and electronic, electrical, magnetic and optical properties of solids with emphasis on some of the most important classes of inorganic materials.

Module-I: (10 Hours)

Electron Theory of Solids: Free Electron Theory of Metals, Electrical Conductivity, Thermal Conductivity, Quantum Theory of Free Electrons, Band Theory of Solids, Conductivity of Metals.

Type of Material based on Conductivity: Conductors, Insulators, Semiconductors, Intrinsic and extrinsic Semiconductors, Band Theory of Conductors, Hall Effect.

Characterization: Thermal Analysis, Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC).

Module-II: (10 Hours)

Super Conductors: Zero Resistivity, Critical Magnetic Field and Critical Current Density, Type I and II Super Conductors, Applications of Superconductors.

Dielectric Materials: Microscopic Displacement of Atoms and Molecules in External DC Electric Field, Polarization and Dielectric Constant, Dielectric Susceptibility, Temperature Dependence of Dielectric Breakdown, Ferroelectric Materials, Piezoelectrics, Pyroelectrics, Dielectric Materials as Electric Insulators.

Magnetic Properties: Dia, Para and Ferromagnetic Materials, Theory of Magnetism, Ferrimagnetic Materials or Ferrites, Comparison of Magnetic Behaviour and Magnetic Parameters of Dia, Para and Ferromagnetic Materials.

Module-III: (10 Hours)

Nanomaterials: Introduction to Nanoscience, History and Scope of Nanoscience, Different Kind of Small, Interdisciplinary Sciences behind Nanotechnology and Nanoscience. Carbon

Nanotubes, Nanowires Quantum Dots, Nanocrystals, Nanoclusters and other Nanostructures.

Synthesis Methods and Strategies: Measuring and Imaging Tools for Nanostructures, Preparation, Synthesis and Fabrication of Nanostructures, Laser Vaporization, Electric Arc, CVD, Laser Pyrolysis, Hydrothermal, Gas Phase Synthesis and Sol-Gel Processing, Self-Assembly.

Module-IV: (10 Hours)

Nanotechnology in Physics, Chemistry, Biology and Engineering: Applications to Nano Electromechanical Systems (NEMS), Nano-optoelectronic Materials and Devices, Medical and Pharmacology Applications, Nanomaterial Thin-films, Optical Limiting Properties, Nanoscale Devices - Transistors, FETs, Quantum Dots Lasers and Other.

Prescribed Books:

1. W.D. Callister and D.G. Rethwisch, *Materials Science and Engineering: An Introduction*, 9th Edition, John Wiley & Sons, 2014.

2. M.S. Vijaya and G. Rangarajan, *Materials Science*, 1st Edition, Tata McGraw-Hill, 2003.

3. V. Rajendran and A. Marikani, *Materials Science*, 1st Edition, Tata McGraw-Hill, 2004.

4. L.H.V. Vlack, *Elements of Material Science and Engineering*, 6th Edition, Pearson education, 1989.

5. C.P. Poole, Jr. and F.J. Owens, *Introduction to Nanotechnology*, 1st Edition, John Wiley & Sons, 2003.

6. M.A. Ratner and D. Ratner, *Nanotechnology: A Gentle Introduction to the Next Big Idea, 1st Edition*, Prentice Hall, 2002.

7. T. Pradeep, Nano: *The Essentials: Understanding Nanoscience and Nanotechnology*, 1st Edition, Tata McGraw-Hill, 2007.

8. Editors of Scientific American, *Understanding Nanotechnology*, 1st Edition, Scientific American, 2002.

9. M. Wilson, K. Kannangara, G. Smith, M. Simmons, and B. Raguse, *Nanotechnology: Basic Science and Emerging Technologies*, 1st Edition, CRC Press, 2002.

10. J. Ramsden, *Nanotechnology: An Introduction*, 1st Edition, Elsevier, 2011.

11. D. Natelson, *Nanostructures and Nanotechnology*, 1st Edition, Cambridge University Press, 2015.

12. B.S. Murty, P. Shankar, B. Raj, B.B. Rath, and J. Murday, *Textbook of Nanoscience and Nanotechnology*, 1st Edition, University Press, 2013.

13. C. Binns, *Introduction to Nanoscience and Nanotechnology*, 1st Edition, John Wiley & Sons, 2010.

14. V.K. Varadan, A.S. Pillai, D. Mukherji, M. Dwivedi, and Linfeng Chen, *Nanoscience and Nanotechnology in Engineering*, 1st Edition, World Scientific, 2010.

Code: **CH-522** Subject: **CHEMISTRY OF MATERIALS** Credits: **4 [4-0-0]**

Course Objective:

- To provide knowledge about the importance of chemistry in understanding various common materials of industrial importance.
- To provide knowledge about nano chemicals and nano composites and their applications.
- To provide knowledge about organic conductors and organic electronics.

Course Outcome:

- To understand and exploit the properties of various chemical materials in day-to-day life.
- To understand how and why the properties of materials are controlled by structure, bonding and processing at the atomic-scale, and by features at the microstructural and macroscopic levels.

Module-I: (10 Hours)

Glasses, Ceramics, Composites, and Nanomaterials: Glassy State, Glass Formers and Glass Modifiers, Applications. Ceramic Structures, Mechanical Properties, Clay Products. Refractories, Characterizations, Properties and Applications. Macroscopic Composites, Dispersion-Strengthened and Particle-Reinforced, Fibre-Reinforced Composites, Macroscopic Composites. Nanocrystalline Phase, Preparation, Procedures, Special Properties, Applications.

Module-II: (10 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-III: (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-IV: (10 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.

Polymeric Materials: Molecular Shape, Structure and Configuration, Crystallinity, Stress-Strain Behaviour, Polymer Types and Their Applications, Conducting and Ferroelectric Polymers.

Prescribed Books:

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 & Sons, 2014.

3. H.V. Keer, *Principles of Solid State*, 1st Edition, New Age International, 1993.

4. J.C. Anderson, K.D. Leaver, R.D. Rawlings, and J.M. Alexander, *Materials Science*, 4th Edition, Springer, 2013.

5. G.W. Gray, *Thermotropic Liquid Crystals*, 1st Edition, John Wiley & Sons, 1987.

6. H. Kelker and R. Hatz, Handbook of Liquid Crystals, 1st Edition, Verlag Chemie, 1980.

7. D. Singh, D. Zhu, W.M. Kriven, S. Mathur, H.-T. Lin, *Design, Development, and Applications of Structural Ceramics, Composites, and Nanomaterials*, 1st Edition, John

Wiley & Sons, 2014.

8. C. S. Sunandana, *Introduction to Solid State Ionics: Phenomenology and Applications*, 1st Edition, CRC Press, 2016.

9. T. Torres and G. Bottari, *Organic Nanomaterials: Synthesis, Characterization, and Device Applications*, 1st Edition, John Wiley & Sons, 2013.

10. M. Ohring, *Materials Science of Thin Films: Deposition and Structure*, 2nd Edition, Academic Press, 2002.

11. F. Mohammad, *Specialty Polymers: Materials and Applications*, 1st Edition, I.K. International, 2007.

Code: **CH–523** Subject: **ORGANIC SYNTHESIS** Credits: **4 [4-0-0]**

Course Objective:

- The objective of the course is for students to develop an understanding of both structure and chemical transformations of organic molecules.
- Students will acquire basic concepts of electronic structure and be able to apply them to solve problems from various synthetic areas of organic chemistry.

Course Outcomes:

- Understanding of organic mechanisms to predict the outcome of reactions.
- Design for the syntheses of organic molecules.
- Information of synthesis and properties of heterocyclic compounds.

Module-I: (10 Hours)

Synthetic Design: Introduction, Retrosynthetic Approach, Terminology in Retro Synthetic Analysis, ONE Group Disconnection, (Alcohol, Carbonyl Compound, Olefins and Acids), Two Group Disconnections (β-Hydroxy Compounds, α, β-Unsubstituted Carbonyl Compounds, 1,3-Dicarbonyl Compounds, 1,5 Dicarbonyl Compounds), Synthesis of Some Organic Molecules by Disconnection Approach.

Module-II: (10 Hours)

Chemo-selectivity, Protecting Group (Alcohol, Amine, Carbonyl, Carboxylic Acids),

Stereoselectivity, Regioselectivity.

Module-III: (10 Hours)

Oxidation: Chromium (VI), Manganese (VII) Oxidants, Oxidation with Per Acids, Oxidation with Hydrogen Peroxide, with Singlet Oxygen and Other Oxidants. Catalytic Hydrogenation, Reduction with Metal Hydrides, the Birch Reduction, Wittig Reaction.

Module-IV: (10 Hours)

General Methods of Synthesis and Reactions of Heterocyclic Compound of Three Members and Four Members.

Prescribed Books:

1. S. Warren and P. Wyatt, *Organic Synthesis: The Disconnection Approach*, 2nd Edition, John Wiley & Sons, 2008.

2. P. Wyatt and S. Warren, *Organic Synthesis: Strategy and Control*, 1st Edition, John Wiley & Sons, 2007.

3. M.B. Smith, *Organic Synthesis*, 3rd Edition, Academic Press, 2011.

4. W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis*, 4th Edition, Cambridge University Press, 2004.

5. W.A. Smit, A.F. Bochkov, and R. Caple, *Organic Synthesis: The Science behind the Art*, 1st Edition, Royal Society of Chemistry, 1998.

6. J.-H. Fuhrhop and G. Li, *Organic Synthesis: Concepts and Methods*, 3rd Edition, John Wiley & Sons, 2003.

7. R.O.C. Norman and J.M. Coxon, *Principles of Organic Synthesis*, 3rd Edition, Chapman & Hall, 1993.

8. B.P. Mundy, M.G. Ellerd, and F.G. Favaloro Jr., *Name Reactions and Reagents in Organic Synthesis*, 2nd Edition, John wiley & sons, 2005.

9. L. Kürti and B. Czakó, *Strategic Applications of Named Reactions in Organic Synthesis: Background and Detailed Mechanisms*, 1st Edition, Elsevier Academic Press, 2005.

10. V. K. Ahluwalia and R. Aggarwal, *Organic Synthesis: Special Techniques*, 1st Edition,

Alpha Science International, 2001.

11. M.H. Nantz, G. Zweifel, and P. Somfai, *Modern Organic Synthesis: An Introduction*, 1st Edition, John Wiley & Sons, 2016.

12. C.L. Willis and M. Wills, *Organic Synthesis*, 1st Edition. Oxford University Press, 1996.

13. L.S. Starkey, Introduction to Strategies for Organic Synthesis, 1st Edition, John Wiley & Sons, 2012.

14. F.A. Carey and R.J. Sundberg, *Advanced Organic Chemistry: Part B: Reaction and Synthesis*, 5th Edition, Springer, 2010.

15. R.S. Macomber, *Organic Chemistry, Volume I & II*, 1st Edition, University Science Books, 1996.

16. L.D.S. Yadav and J. Singh, *Organic Synthesis*, 1st Edition, Pragati Prakashan, 2015.

17. C.K. Charles, *Organic Synthesis*, 1st Edition, Alpha Science International, 2012.

18. P.S. Kalsi, *Organic Synthesis through Disconnection Approach*, 1st Edition, Medtec/ Scientific International, 2014.

19. R.E. Ireland, *Organic Synthesis*, 1st Edition, Prentice Hall, 1969.

20. T.J. Donohoe, *Oxidation and Reduction in Organic Synthesis*, 1st Edition, Oxford University Press, 2000.