**CENTRAL UNIVERSITY OF HARYANA**

**SCHOOL OF BASIC SCIENCES**

**DEPARTMENT OF CHEMISTRY**

**M.Sc. Chemistry**

**SEMESTER-I (24-Credits)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No** | | **Course code** | | **Course title** | | **L** | **T** | | | **P** | | **Hrs/**  **week** | | **Total**  **Credits** | |
| **CORE COURSES** | | | | | | | | | | | | | | | |
| 1. | | SBS CH 010101 C 4004 | | Inorganic Chemistry-I | | 4 | 0 | | | 0 | | 4 | | 4 | |
| 2. | | SBS CH 010102 C 4004 | | Organic Chemistry-I | | 4 | 0 | | | 0 | | 4 | | 4 | |
| 3. | | SBS CH 010103 C 4004 | | Physical Chemistry-I | | 4 | 0 | | | 0 | | 4 | | 4 | |
| 4. | | SBS CH 010104 C 0042 | | Inorganic Chemistry Practical-I | | 0 | 0 | | | 4 | | 4 | | 2 | |
|  | | SBS CH 010105 C 0042 | | Organic Chemistry Practical-I | | 0 | 0 | | | 4 | | 4 | | 2 | |
| 5. | | SBS CH 010106 C 0042 | | Physical Chemistry Practical-I | | 0 | 0 | | | 4 | | 4 | | 2 | |
| **DISCIPLINE CENTRIC ELECTIVE COURSES** | | | | | | | | | | | | | | | |
| **Sr. No.** | **Course Code** | | **Course Title** | | **L** | | | **T** | **P** | | **Hrs/week** | | **Total Credits** | |
| 1. | SBS CH 010101 DCEC 2002 | | Household and Applied Chemistry | | 2 | | | 0 | 0 | | 2 | | 2 | |
| 2. | SBS CH 010102 DCEC 2002 | | Reaction Mechanism: Structure and Reactivity | | 2 | | | 0 | 0 | | 2 | | 2 | |
| 3. | SBS CH 010103 DCEC 2002 | | Chemistry of Nutraceuticals | | 2 | | | 0 | 0 | | 2 | | 2 | |

**GENERIC ELECTIVE COURSES**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | SBS CH 010101 GEC 4004 | Chemistry of Materials | 4 | 0 | 0 | 4 | 4 |
| 2. | SBS CH 010102 GEC 4004 | Basic Concepts in Chemistry | 4 | 0 | 0 | 4 | 4 |
| 3. | SBS CH 010103 GEC 4004 | Chemistry for Biologists | 4 | 0 | 0 | 4 | 4 |

**CENTRAL UNIVERSITY OF HARYANA**

**SCHOOL OF BASIC SCIENCES**

**DEPARTMENT OF CHEMISTRY**

**M.Sc. Chemistry**

**SEMESTER-II (24-Credits)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No** | | **Course code** | **Course title** | | | **L** | **T** | | **P** | | **Hrs/**  **week** | | **Total**  **Credits** | | |
| **CORE COURSES** | | | | | | | | | | | | | | | |
| 1. | | SBS CH 010207 C 4004 | Inorganic Chemistry-II | | | 4 | 0 | | 0 | | 4 | | 4 | | |
| 2. | | SBS CH 010208 C 4004 | Organic Chemistry-II | | | 4 | 0 | | 0 | | 4 | | 4 | | |
| 3. | | SBS CH 010209 C 4004 | Physical Chemistry-II | | | 4 | 0 | | 0 | | 4 | | 4 | | |
| 4. | | SBS CH 010210 C 0042 | Inorganic Chemistry Practical-II | | | 0 | 0 | | 4 | | 4 | | 2 | | |
|  | | SBS CH 010211 C 0042 | Organic Chemistry Practical-II | | | 0 | 0 | | 4 | | 4 | | 2 | | |
| 5. | | SBS CH 010212 C 0042 | Physical Chemistry Practical-II | | | 0 | 0 | | 4 | | 4 | | 2 | | |
| **DISCIPLINE CENTRIC ELECTIVES COURSES** | | | | | | | | | | | | | | | |
| 1. | SBS CH 010204 DCEC 2002 | | | Green and Sustainable Chemistry | 2 | | | 0 | | 0 | | 2 | | 2 |
| 2. | SBS CH 010205 DCEC 2002 | | | Introduction to Nanomaterials | 2 | | | 0 | | 0 | | 2 | | 2 |
| 3. | SBS CH 010206 DCEC 2002 | | | Analytical Techniques in Chemistry | 2 | | | 0 | | 0 | | 2 | | 2 |
| 4. | SBS CH 010207 DCEC 2002 | | | Computational Chemistry | 2 | | | 0 | | 0 | | 2 | | 2 |
| 5. | SBS CH 010208 DCEC 2002 | | | Carbohydrates: Chemistry and Applications | 2 | | | 0 | | 0 | | 2 | | 2 |
| 6. | SBS CH 010209 DCEC 2002 | | | Nanoparticulate Drug-Delivery Systems | 2 | | | 0 | | 0 | | 2 | | 2 |

**GENERIC ELECTIVE COURSES**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | SBS CH 010204 GEC 4004 | Environmental Chemistry | 4 | 0 | 0 | 4 | 4 |
| 2. | SBS CH 010205 GEC 4004 | Chemistry in Everyday Life | 4 | 0 | 0 | 4 | 4 |
| 3. | SBS CH 010206 GEC 4004 | Nuclear and Magnetochemistry | 4 | 0 | 0 | 4 | 4 |

**CENTRAL UNIVERSITY OF HARYANA**

**SCHOOL OF BASIC SCIENCES**

**DEPARTMENT OF CHEMISTRY**

**M.Sc. Chemistry**

**SEMESTER-III (24-Credits)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No** | **Course code** | **Course title** | **L** | **T** | **P** | **Hrs/**  **week** | **Total**  **Credits** |
| **CORE COURSES (COMPULSORY, 2X4 = 8 Credit)** | | | | | | | |
| 1. | SBS CH 010313 C 4004 | Applications of Spectroscopy | 4 | 0 | 0 | 4 | 4 |
| 2. | SBS CH 010314 C 4004 | Molecular Spectroscopy | 4 | 0 | 0 | 4 | 4 |
| **SPECIALISED ELECTIVES** | | | | | | | |
| 1. | SBS CH 010301 SE 4004 | Inorganic Chemistry-III | 4 | 0 | 0 | 4 | 4 |
| 2. | SBS CH 010302 SE 4004 | Inorganic Chemistry-IV | 4 | 0 | 0 | 4 | 4 |
| 3. | SBS CH 010303 SE 0084 | Inorganic Chemistry Practical-III | 0 | 0 | 8 | 4 | 4 |
| **OR** | | | | | | | |
| 4. | SBS CH 010304 SE 4004 | Organic Chemistry-III | 4 | 0 | 0 | 4 | 4 |
| 5. | SBS CH 010305 SE 4004 | Organic Chemistry-IV | 4 | 0 | 0 | 4 | 4 |
| 6. | SBS CH 010306 SE 0084 | Organic Chemistry Practical-III | 0 | 0 | 8 | 4 | 4 |
| **OR** | | | | | | | |
| 7. | SBS CH 010307 SE 4004 | Physical Chemistry-III | 4 | 0 | 0 | 4 | 4 |
| 8. | SBS CH 010308 SE 4004 | Physical Chemistry-IV | 4 | 0 | 0 | 4 | 4 |
| 9. | SBS CH 010309 SE 0084 | Physical Chemistry Practical-III | 0 | 0 | 8 | 4 | 4 |

**DISCIPLINE CENTRIC ELECTIVE COURSES**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | SBS CH 010310 DCEC 4004 | Waste Management | 4 | 0 | 0 | 2 | 4 |
| 2. | SBS CH 010311 DCEC 4004 | Chemistry of Toxic Substances | 4 | 0 | 0 | 2 | 4 |
| 3. | SBS CH 010312 DCEC 4004 | Environmental Chemistry | 4 | 0 | 0 | 2 | 4 |
| 4. | SBS CH 010313 DCEC 2002 | Agrochemicals | 2 | 0 | 0 | 2 | 2 |
| 5. | SBS CH 010314 DCEC 2002 | Industrial Chemistry | 2 | 0 | 0 | 2 | 2 |
| 6. | SBS CH 010315 DCEC 2002 | Carbon Management | 2 | 0 | 0 | 2 | 2 |
| 7. | SBS CH 010316 DCEC 2002 | Pharmaceutical Chemistry | 2 | 0 | 0 | 2 | 2 |
| 8. | SBS CH 010317 DCEC 2002 | Enzymes: Chemistry and Applications | 2 | 0 | 0 | 2 | 2 |

**GENERIC ELECTIVE COURSES**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | SBS CH 010307 GEC 4004 | Green Chemistry | 4 | 0 | 0 | 4 | 4 |
| 2. | SBS CH 010308 GEC 4004 | Drug Design and Discovery | 4 | 0 | 0 | 4 | 4 |

**CENTRAL UNIVERSITY OF HARYANA**

**SCHOOL OF BASIC SCIENCES**

**DEPARTMENT OF CHEMISTRY**

**M.Sc. Chemistry**

**SEMESTER-IV (24-Credits)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No** | **Course code** | **Course title** | **L** | **T** | **P** | **Hrs/ week** | **Total**  **Credits** | |
| **CORE COURSES (COMPULSORY, 14 Credit)** | | | | | | | | |
| 1. | SBS CH 010415 C 00 2814 | Research Project | 0 | 0 | 28 | 28 | | 14 |
| **SPECIALISED ELECTIVES** | | | | | | | | |
| 1. | SBS CH 010410 SE 4004 | Inorganic Chemistry-V | 4 | 0 | 0 | 4 | 4 | |
| 2. | SBS CH 010411 SE 4004 | Inorganic Chemistry-VI | 4 | 0 | 0 | 4 | 4 | |
| **OR** | | | | | | | | |
| 3. | SBS CH 010412 SE 4004 | Organic Chemistry-V | 4 | 0 | 0 | 4 | 4 | |
| 4. | SBS CH 010413 SE 4004 | Organic Chemistry-VI | 4 | 0 | 0 | 4 | 4 | |
| **OR** | | | | | | | | |
| 5. | SBS CH 010414 SE 4004 | Physical Chemistry-V | 4 | 0 | 0 | 4 | 4 | |
| 6. | SBS CH 010415 SE 4004 | Physical Chemistry-VI | 4 | 0 | 0 | 4 | 4 | |

**DISCIPLINE CENTRIC ELECTIVE COURSES**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | SBS CH 010418 DCEC 2002 | Adsorption Science and Technology | 2 | 0 | 0 | 2 | 2 |
| 2. | SBS CH 010419 DCEC 2002 | Asymmetric Catalysis: Fundamentals to Frontiers | 2 | 0 | 0 | 2 | 2 |
| 3. | SBS CH 010420 DCEC 2002 | Toxicology Lab | 0 | 0 | 4 | 2 | 2 |
| 4. | SBS CH 010421 DCEC 2002 | Molecules of Life | 2 | 0 | 0 | 2 | 2 |
| 5. | SBS CH 010422 DCEC 2002 | Molecular Magnetism | 2 | 0 | 0 | 2 | 2 |
| 6. | SBS CH 010423 DCEC 2002 | Analytical Chemistry | 2 | 0 | 0 | 2 | 2 |
| 7. | SBS CH 010424 DCEC 2002 | Antibiotic and Anti-inflammatory Agents: Chemistry and Applications | 2 | 0 | 0 | 2 | 2 |

**GENERIC ELECTIVE COURSES**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | SBS CH 010409 GEC 4004 | Materials and Nuclear Chemistry | 4 | 0 | 0 | 4 | 4 |
| 2. | SBS CH 010410 GEC 4004 | Medicinal Chemistry | 4 | 0 | 0 | 4 | 4 |

**SEMESTER-WISE SYLLABUS**

**INORGANIC CHEMISTRY COURSES**

**SEMESTER - I**

Course Name - Inorganic Chemistry-I

**Course Code - SBS CH 010101 C 4004**

**Credits: 4**

# 

***Course Objective and Learning Outcomes:***

*To provide students with basic understanding of symmetry, coordination chemistry, magnetic properties of coordination complexes, metal carbonyl/nitrosyl and metal clusters. This course will strengthen the fundamentals of inorganic chemistry, especially the coordination chemistry and would help students to appreciate color and magnetism exhibited by inorganic compounds.*

**UNIT I: SYMMETRY, STRUCTURE AND COORDINATE POLYMERS IN INORGANIC COMPOUNDS**

Symmetry elements and symmetry operations, symmetry groups with examples from inorganic compounds, groups of very high symmetry, molecular dissymmetry and optical activity, molecular symmetry of coordination compounds, matrix representations of symmetry operators and their products. Valence bond theory, electroneutrality principle and limitations, Brief introduction of coordination polymers-1D, 2D, 3D coordination polymers and interpenetration.

**UNIT II: COORDINATION COMPOUNDS**

Crystal field theory, splitting of *d*-orbitals in octahedral, tetragonal, square planar and tetrahedral ligand environments. Structural consequences of splitting of *d*-orbitals, Jahn-Teller theorem, trends in ionic radii, lattice energy and heat of ligation. Structure of spinels. MOT with σ and *π*-bonding.

Brief review of different types of magnetic behaviors, spin-orbit coupling, quenching of orbital angular moments. Term symbols for metal ions, crystal field theory and its application to explain magnetic properties of coordination compounds.

**UNIT III: CHEMISTRY OF NON TRANSITION ELEMENTS**

Structures and acidic behaviour of boron halides, Types and nomenclature boron hydrides (boranes), Wade’s polyhedral skeleton electron pair theory (PSEPT). W. N. Lipscomb’s STYX rules and semi-topological structures of boranes.Preparation, and properties of boron hydrides, carboranes, metalloboranes and metallocarboranes. Preparation, structure and properties of borazines, phosphazenes, phosphorus-oxygen, sulphur-nitrogen compounds, silicates, interhalogens, Chlorofluorocarbons, pseudohalides and noble gas compounds.

**UNIT IV: METAL CARBONYLS, NITROSYLS AND CLUSTERS**

Molecular orbital of carbonyl, classification of metal carbonyls, bonding in metal carbonyl, valence electron count (EAN rules), preparation and properties of mononuclear and polynuclear carbonyl complexes, bond lengths and stretching frequencies, carbonylate ions, carbonyl hydride complexes, isolobal fragments, structure and important reactions of transition metal nitrosyl. Bonding, preparation and properties of dinuclear metal cluster (dirhenium complex [Re2Cl8]2- ions), trinuclear and hexanuclear metal clusters.

#### Suggested Readings:

1. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and Its Applications, Wiley-India, 2010.
2. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6th ed. John Wiley, 2006.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed. Pearson Education, 2006.
4. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2nd ed. Butterworth- Heinemann, 1997.
5. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edn., Oxford University Press, 1998.
6. J. D. Lee, Concise Inorganic Chemistry, Chapman & Hall Ltd., 1991.
7. R. L. Magnetochemistry, Carlin, Springer Verlog. Heidelberg, New York, Tokyo, 1986.
8. A. Earnshaw, Magnatochemistry, 1st ed. Academic Press, 1968.

**SEMESTER-I**

Course Name - Inorganic Chemistry Practical-I

**Course Code - SBS CH 010104 C 4004**

**Credits: 2**

# 

***Course Objective and Learning Outcomes:***

*To train students with preparation of various inorganic complexes/compounds, water analysis and identification of acidic and basic radicals. Much of the understanding acquired from the theory paper (Inorganic Chemistry I) would be validated with the performed experiments.*

*At the end of the course students will have first-hand expertise of performing simple inorganic experiments independently.*

**UNIT 1: WATER AND RADICAL ANALYSIS**

**(a) Water Analysis (Any Two)**

1. Determination of DO, COD and BOD of a waste water sample.

2. Determination of total suspended solids and total dissolved solids.

3. Determination of turbidity of a water sample by nephlometer.

**(b) Radical Analysis**

Analysis of simple mixtures of acidic and basic radicals.

**UNIT 2: PREPARATIONS AND RELATED COMPLEMENTARY WORK AND PHYSICAL STUDIES (ANY FOUR)**

1. Reinecke Salt

2. VO(acac)2

3. Mn(acac)3

4. Prussian Blue/Turnbull’s Blue

5. Hg[Co(NCS)4]

6. Potassium trioxalatoferate (III) Trihydrate

7. Potassium trioxaltochromate (III)

8. Cis, trans-dichloro bis(ethylenediammine) cobalt(III)chloride.

#### Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel’s Textbook of Quantitative Analysis, revised, 5th ed. ELBS, 1989.

2. G. Svehla, Vogel’s Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5th ed. Longman, 1979.

3. Marr and Rocket, Practical Inorganic Chemistry, Van Nostrand Reinhold, 1972.

**SEMESTER - II**

Course Name - Inorganic Chemistry –II

Course Code - SBS CH 010207 C 4004

Credits: 4



***Course Objective and Learning Outcomes:***

*To provide an understanding of the fundamentals of electronic spectroscopy of coordination compounds and advanced topics such as, reaction mechanism in complexes. Introductory nuclear chemistry and its theory will be discussed as well.*

*At the end of the course students will be able to appreciate the kinetics and thermodynamics associated with the reactions of inorganic compounds and enjoy the flavor of nuclear chemistry.*

**UNIT I: REACTION MECHANISMS 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 reaction in square planar complexes, *trans* effect, mechanism of the substitution reactions. Redox reactions, mechanism of inner-outer sphere type reactions, cross reactions and Marcus-Hush theory.

**UNIT II: ELECTRONIC SPECTROSCOPY OF TRANSITION METAL COMPLEXES**

Spectroscopic ground states and the evaluation of energies of various J states of free ions, splitting of S, P, D and F terms under octahedral and tetrahedral electrostatic potential, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d1-d9 states), calculations of Dq, B and β parameters, charge transfer spectra of complexes (both metal to ligand and ligand to metal), spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information.

**UNIT III: METAL-LIGAND EQUILIBRIA IN SOLUTION**

Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors influencing stability of metal complexes dependent on size and charge, metal class, ligand preference, nature of transition metal ions, basic strength, chelate effect, ring size, steric strain, macrocyclic effect, thermodynamic and kinetic stability, determination of formation constants by pH-metry and spectrophotometry.

**UNIT IV: RADIOACTIVITY AND NUCLEAR CHEMISTRY**

Nuclear binding energy, nuclear emissions, nuclear transformations, kinetics of radioactive decay, bombardment of nuclei, nuclear fission, nuclear fusion, kinetic isotope effects, radiocarbon dating, chemical separation, Szilard–Chalmer’s effect, effects of radiation on life, radioactivity in medicines.

#### Suggested Readings:

1. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rd ed. Willey, 2013.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi; Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed. Pearson Education, 2006.
3. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. John Wiley, 1999.
4. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edn., Oxford University Press, 1998.
5. N. N. Greenwood and E. A. Earnshaw: Chemistry of elements, 2nd ed. Butterworth- Heinemann, 1997.
6. B. E. Douglas, D. H. McDaniel, J. J. Alexander; Concepts and Models of Inorganic Chemistry, 3rd ed. John Wiley, 1993.
7. J. D. Lee, Concise Inorganic Chemistry, Chapman & Hall Ltd., 1991.
8. H. J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern, 1988.

**SEMESTER-II**

Course Name - Inorganic Chemistry Practical-II

**Course Code - SBS CH 010210 C 0042**

# **Credits: 2**

# 

***Course Objective and Learning Outcomes:***

*To train students with quantitative estimation of metal ions (single and mixtures) and identification of mixture of radicals (acid and basic including interfering radicals).*

*At the end of the course students will have first-hand expertise of performing simple inorganic experiments independently and acquired the skill of carrying out redox and complexometric titrations.*

**UNIT I: QUANTITATIVE ESTIMATION**

Quantitative estimation (involving volumetric-redox and complexometry) of constituents in two and three component mixtures.

**UNIT II: SEMIMICRO QUALITATIVE ANALYSIS**

Complete systematic analysis of Inorganic mixtures containing six ions including the interfering radicals.

#### Suggested Readings:

1. Vogel’s Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, 5th ed. ELBS, 1989.
2. Vogel’s Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, G. Svehla, 5th ed. Longman, 1979.
3. Practical Inorganic Chemistry, Marr and Rocket, Van Nostrand Reinhold, 1972.

**SEMESTER-III**

**Course Name - Inorganic Chemistry-III (Bioinorganic Chemistry)**

**Course Code - SBS CH 010301 SE 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide exposure of various biomolecules containing metal ions that comprise many important proteins and enzymes; and important biological processes such as nitrogen fixation and photosynthesis. This course would be highly beneficial for students who had minimal exposure of bioinorganic chemistry at the undergraduate level.*

**UNIT I: METAL IONS IN BIOLOGY**

Essential and trace elements in biological systems. Calcium in biology: Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes. Role in muscle contraction, blood clotting mechanism and biological calcification. Biochemistry of sodium and potassium, membrane structure, mechanism of ion transport across membranes, Na+/K+ Pump, biological defense mechanism, ionophores.

#### UNIT II: NITROGEN FIXATION AND PHOTOSYNTHESIS

Biological nitrogen fixation, introduction of nitrogenase, iron-sulfur clusters, Fe-protein structure, MoFe-protein structure, details of P-cluster and FeMo-cluster, nitrogenase model systems. Chlorophylls, structure of chlorophyll, photosystem I and photosystem II in cleavage of water. Model systems.

#### UNIT III: METALLOPROTEINS

Structure and function of metalloproteins in electron transport processes– cytochromes and iron-sulphur proteins, synthetic models. Heme proteins and oxygen uptake, myoglobin and hemoglobin basics, structure of the prosthetic group, mechanism for reversible binding of dioxygen and cooperativity of oxygen binding of myoglobin and hemoglobin, structure and function of hemocyanins and hemerythrin.

#### UNIT IV: ENZYMES IN BIOLOGICAL SYSTEMS

Introduction and historical perspective of enzymes, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Zinc enzymes-carboxypeptidase and carbonic anhydrase. Iron enzymes- catalase, peroxidase and cytochrome P-450. Copper enzymes- superoxide dismutase. Molybednum oxatransferase enzymes-xanthine oxidase. Coenzyme vitamin B12.

#### Suggested Readings:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed. Pearson Education, 2006.
2. J. A. Cowan, Inorganic Biochemistry-An Introduction, Wiley-VCH, 1997.
3. S. J. Lippard, J. M. Berg, Principles of Bioinorganic Chemistry, University Science Book, Mill Valley, 1994.
4. I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentne, Bioinorganic Chemistry, University Science Books, Mill Valley, CA (USA), 1994.
5. E. I. Ochiai, Bioinorganic Chemistry-An Introduction, Allyn and Bacon, Inc., 1977.
6. R. W. Hay, Bioinorganic Chemistry, Ellis Hollwood, 1984.

SEMESTER-III

Course Name - Inorganic Chemistry-IV (Spectroscopy and Photoinorganic Chemistry)

**Course Code - SBS CH 010302 SE 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide students exposure with various spectroscopic techniques (IR, Raman, ESR, Mossbauer, NQR) required to characterize inorganic complexes and coordination compounds. An introduction of photoinorganic chemistry involving various photophysical processes would be covered as well.*

**UNIT I: INFRARED AND RAMAN SPECTROSCOPY**

Molecular vibrations, force constants, molecular vibrations and absorption of Infrared radiations. Raman spectroscopy, polarized Raman lines. Use of symmetry considerations to determine the number of lines in IR and Raman Spectra. Structural studies involving IR and Raman Spectroscopy of coordination compounds containing the following molecules/ions and ligands: NH3, H2O, OH, SO42-, ClO4-, COO-, NO2, CN-, SCN-, NO, O2, halides, acetylacetone. Hydrogen bonding and infrared spectra, metal ligand and related vibrations. Application of resonance Raman spectroscopy to structural elucidation of the active sites of heme and non-heme oxygen carriers.

**UNIT II: ELECTRON SPIN RESONANCE SPECTROSCOPY**

Basic principle, selection rules, presentation of spectra, origin and interpretation of Lande’s factor(g), factor affecting ‘g-value’, isotropic and anisotropic hyperfine coupling, super hyperfine coupling, spin-orbit coupling, line shape, zero field splitting, Kramer’s degeneracy, quadrupolar interactions, ESR analysis of organic compounds, transition metal complexes of vanadium, chromium, manganese, iron, copper, cobalt and iron.

Application of ESR spectroscopy: structure determination, interpretation of ESR spectra of simple organic radicals like benzene, naphthalene, toluene and xylene radical ions, study of unstable paramagnetic species.

**UNIT III: MÖSSEBAUER AND NUCLEAR QUADRUPOLE RESONANCE SPECTROSCOPY**

Mössebauer Spectroscopy: Introduction to Mössebauer effect-Basic principles, recoilless emission & absorption of γ-rays. Mössebauer experiment - Instrumentation, scheme of Mössebauer spectrometer, Mössebauer spectrum. Isomer shift, quadrapole splitting and hyperfine interactions, application of Mössebauer effect to the investigations of compounds of iron and tin.

Nuclear Quadrupole Resonance Spectroscopy: Principle, nuclear quadrupole resonance experiment, structural information from NQR spectra, Interpretation of nuclear quadrupole coupling constants.

**UNIT IV: PHOTOINORGANIC CHEMISTRY**

Interaction of electromagnetic radiation with matter, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beer’s law, quantum yield, photodissociation, predissociation, photochemical reactions: photoreduction, photooxidation, photodimerization, photochemical substitution, photoisomerization, photosensitized reaction.

Eectronic transition, Frank-Condon principle, selection rules, electronically excited singlet states, life time of electronically excited state, construction of Jablonski diagram, electronic transitions and intensity of absorption bands, photophysical pathways of excited molecular system (radiative and non-radiative), chemiluminescence, phosphorescence and fluorescence.

#### Suggested Readings:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5th ed. Cengage India, 2015.
2. K. K. Rohatgi and K. K. Mukherjee; Fundamentals of Photochemistry, 3rded. New Age International (P) Ltd., 2014.
3. K. Nakamoto; Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A and B, 6th ed. Wiley, 2008.
4. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, 3rd ed. Springer, New York, 2006.
5. N. J. Turro, V. Ramamurthy and J. C. Scaiano, Modern Molecular Photochemistry of Organic Molecules, 1st ed. University Science, Books, CA, 2010.
6. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th ed. Tata McGraw Hill, 1994.
7. I. Ninomiya and T. Naito, Photochemical Synthesis, 1st ed. Academic Press, New York, 1989.

**SEMESTER-III**

Course Name - Inorganic Chemistry Practical-III

**Course Code - SBS CH 010303 SE 0084**

# **Credits: 4**

# 

***Course Objective and Learning Outcomes:***

*To provide students exposure of chromatography and gravimetric experiments. Advanced experiments such as growing of single-crystals and their identification using polarizing optical microscope will be carried out. First-hand experience of UV-Visible and FTIR spectroscopic studies will be provided. At the end of this course students will gain skills of characterizing compounds and will be equipped to perform experiments at the research level.*

UNIT I: CHROMATOGRAPHY

Separation of binary mixtures in the given solution by paper chromatography, visualizing solution: concentrated ammonia, ascending chromatography.

UNIT II: GRAVIMETRY

To prepare solutions of different metal ions and estimate the metal ions gravimetrically. Three component metal ion analysis (one volumetric and two gravimetric method).

UNIT III: SINGLE-CRYSTALS

Methods of growing single-crystals: (i) Diffusion method; (ii) Hydrothermal and Solvothermal method; (ii) Slow evaporation method. To grow single-crystals of molecular compounds, metal-organic cages and metal-organic higher dimensional compounds. Identification of single-crystals under polarizing optical microscope.

UNIT IV: SPECTROSCOPIC STUDIES

Data plotting, analysis and characterization of coordination compounds using Infrared and UV-Visible Spectroscopy.

#### Suggested Readings:

1. Vogel’s Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, 5th ed. ELBS, 1989.
2. Vogel’s Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, G. Svehla, 5th ed. Longman, 1979.
3. Practical Inorganic Chemistry, Marr and Rocket, Van Nostrand Reinhold, 1972.

**SEMESTER-IV**

Course Name - Inorganic Chemistry-V (Organometallic Chemistry)

**Course Code - SBS CH 010410 SE 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*Detailed study of bonding, structure, synthesis and reactions of various types of organometallic complexes will be done. Metal complexes of carbons at various oxidation levels will be discussed. Synthesis and stability, precautions in handling, characterisation techniques and utility or TM-complexes will be studied. The applications of metal complexes in catalysis will be studied in detail. At the end of the course, students are expected to have clear knowledge about the bonding, structure, stability and reactions of various organometallics and their usefulness.*

**UNIT I: ALKYLS, ARYLS, CARBENES AND CARBYNES OF TRANSITION METALS**

Synthesis, structure and bonding considerations of Zeise’s salt; synthesis, stability and decomposition pathways of organocopper in organic synthesis; synthesis and reactivity of alkyl lithium; synthesis and reactivity of organozinc compounds.

Metal carbenes: preparation, reactivity, structure and bonding considerations of Fischer and Schrock carbene complexes, Tebbe’s reagent, Grubb’s reagent, Petasis reagent, Metal carbines: synthesis, reactivity, structure and bonding considerations of Fischer and Schrock carbyne complexes.

**UNIT II: TRANSITION METAL Π-CYCLIC COMPLEXES**

Half and bent sandwich compounds, molecular orbitals of metallocenes, structures of cyclopentadienyl compounds, covalent versus ionic bonding, 18 electron rule, synthesis, structure, aromatic behaviour of Ferrocene, reactions such as metallation, Friedel Craft, Mannich reaction, sulphonation, nitrations, halogenations reactions, Synthesis, structure and reactions of other metallocenes (with Cr, Ni and Zr metals).

**UNIT III: FLUXIONAL ORGANOMETALLIC COMPOUNDS AND COUPLING REACTIONS**

Rates of rearrangement and techniques of study, NMR study of Fluxional behavior, Classification of fluxional organometallic Compounds, Mechanism of fluxionality in compounds of η1-cyclopentadienyls and η3–allyls. Stereochemical non rigidity in case of coordination numbers- 4 & 5 (*cis-trans*, atomic inversion, Berry Pseudorotation).

Tsuji-Trost, Mizoroki-Heck, Miyaura-Suzuki, Stille, Negishi, Sonogashira, Kumada, Hiyama, Buchwald-Hartwig amination or coupling reactions.

**UNIT IV: CATALYTIC PROCESSES INVOLVING TRANSITION METAL ORGANOMETALLIC COMPOUNDS**

Oxidative addition, reductive elimination, insertion-migration reactions, C-H bond activation catalytic mechanism of hydrogenation, hydroformylation, oxidation and isomerization of alkenes, Monsanto acetic acid synthesis, olefin metathesis, Fischer-Tropsch synthesis and Ziegler-Natta polymerization of alkenes, water gas shift reaction, asymmeteric and supported organometallic catalysis.

#### Suggested Readings:

1. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd ed. Pearson, 2018.
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, John Wiley, 5th ed. 2009.
3. R. C. Mehrotra and A. Singh, Organometallic Chemistry, New Age International, 2nd ed. 2007.
4. R. B. Jordan, Reaction Mechanism of Inorganic and Organometallic systems; 2nd ed.; Oxford University Press, 3rd ed. 2007
5. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed. Pearson Education, 2006.

**SEMESTER-IV**

Course Name - Inorganic Chemistry-VI (Materials and Supramolecular Chemistry)

**Course Code - SBS CH 010411 SE 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide exposure of nanomaterials and hybrid materials (covering synthesis, characterization and application) and various aspects of supramolecular chemistry (with basic understanding and applications).*

**UNIT 1: NANOMATERIALS AND NANOCOMPOSITES**

Nanomaterials: An Introduction. Nanomaterials and Nanocomposites. Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials. Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes. Radio- and Microwave Plasma Processes. Flame Aerosol Process.

Characterization of Nanomaterials: Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy.

Nanotubes, Nanorods, and Nanoplates. One-Dimensional Crystals, Carbon Nanotubes and Graphene, Nanotubes and Nanorods from Materials other than Carbon, Synthesis.

**UNIT 2: HYBRID MATERIALS**

Coordination Polymers, Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers-Solvothermal/Hydrothermal, Sonochemical, Microwave, Mechanochemical. Characterization: X-ray diffraction and Spectroscopic Methods. Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery. Zeolitic Metal-Organic Frameworks.

**UNIT 3: SUPRAMOLECULAR CHEMISTRY AND NATURE OF INTERACTIONS**

Definition and Development of Supramolecular Chemistry: Host-Guest Chemistry, Classification of Supramolecular Host-Guest Compounds, Receptors, Coordination and the Lock and Key Analogy, Cooperativity and the Chelate Effect, Preorganisation and Complementarity, Thermodynamic and Kinetic Selectivity, and Discrimination.

Nature of Supramolecular Interactions: Ion–ion, Ion–Dipole, Dipole–Dipole, Hydrogen Bonding, Cation–π, Anion-π, π–π, Van der Waals Forces and Crystal Close Packing, Closed Shell Interactions. Solvation and Hydrophobic Effects. Supramolecular Concepts and Design.

**UNIT 4: SUPRAMOLECULAR CHEMISTRY OF LIFE AND MOLECULAR DEVICES**

Biological Inspiration for Supramolecular Chemistry- Rhodopsin: A Supramolecular Photonic Device, Porphyrins and TetrapyrroleMacrocycles-The Role of Magnesium Tetrapyrrole Complexes. Uptake and Transport of Oxygen by Hemoglobin.

Cation-Binding Hosts: Supramolecular Cation Coordination Chemistry-The Crown Ethers- Discovery and Scope, The Cryptands, The Calixarenes-cation Complexation by Hybrid Calixarenes. Molecular Devices: Supramolecular Photochemistry-Bipyridyl-Type Light Harvesting Devices. Molecule-Based Electronics- Molecular Wires, Molecular Rectifiers, Molecular Switches.

#### Suggested Readings:

1. C. Wu, Inorganic Two Dimensional Materials, Royal Society of Chemistry, 2017.
2. S. Kaskel, The Chemistry of Metal-Organic Frameworks, Vol. 1, Wiley-VCH, 2016.
3. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley-VCH, 2013.
4. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials, World Scientific, 2013.
5. J. W. Steed, Supramolecular Chemistry: From Molecules to Nanomaterials, Vol. 8, Set Ed., John Wiley & Sons, 2012.
6. L. R. Macgillivray, Metal-Organic Frameworks: Design and Applications, Wiley, 2010.
7. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, 2nd Ed., Wiley, 2009.
8. J.-M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, Wiley, 2006.

**ORGANIC CHEMISTRY COURSES**

SEMESTER-I

**Course Name - Organic Chemistry-I**

**Course Code - SBS CH 010102 C 4004**

### Credits: 4



***Course Objective and Learning Outcomes:***

## To provide the basics in Organic Chemistry at the beginning of the semester. At the end of this course, students will gain the knowledge about the nature of bonding in organic molecules, delocalized chemical bonding, aromaticity, stereochemistry, such as conformation and configuration, RS and EZ notations and mechanistic aspects of aliphatic and aromatic nucleophilic substitution and electrophilic aromatic substitutions and elimination reactions.

## UNIT I: NATURE OF BONDING IN ORGANIC MOLECULES

Delocalized chemical bonding-conjugation, cross conjugation, resonance, rules of resonance, effect on reactivity, hyperconjugation, tautomerism; Energy level of π–molecular orbitals, Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Hückel’s rule, annulenes, anti-aromaticity, homo-aromaticity; bonding in fullerenes. Fundamentals of Supramolecular Chemistry, Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

#### UNIT II: STEREOCHEMISTRY

***Conformational analysis*:**  Simple alkanes, cycloalkanes, decalins, conformational lock, ring strain, effect of conformation on reactivity.

***Chirality*:** Basic principles, molecules with more than one chiral center, threo and erythro isomers, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes); Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis: basic principles, chiral pool, auxiliary, substrate, reagent and catalyst controlled.

**UNIT III: ALIPHATIC NUCLEOPHILIC SUBSTITUTION AND ELIMINATION REACTIONS**

***a) Aliphatic Nucleophilic Substitution Reactions:***

The SN2, SN1, mixed SN1 and SN2 and SET Mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The SNi mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambidentnuleophile, regioselectivity.

***b) Elimination Reactions:***

The E2, E1 and E1cB mechanisms. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium.

**UNIT IV: AROMATIC SUBSTITUTION REACTIONS**

***a) Aromatic Electrophilic Substitution:***

The arenium ion mechanism, orientation and reactivity. The *ortho/para* ratio, *ipso* attack, orientation in other ring systems. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

***b) Aromatic Nucleophilic Substitution:***

The SNAr, diazonium salts and benzyne mechanisms. Reactivity–effect of substrate structure, leaving group and attacking nucleophile. The *von* Richter, Sommelet-Hauser and Smiles rearrangements.

#### Suggested Readings:

1. R. N. Boyd, R. T. Morrison and S. K. Bhattcharjee, Organic Chemistry, 7th ed., Pearson, 2014.
2. M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th ed., WILEY, 2013.
3. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, Oxford University Press, 2012.
4. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, Wiley India, 2008.
5. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A, Springer 2007.
6. P. Y. Bruce, Organic Chemistry, 7th Ed., Pearson, 2007.
7. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan, 2007.
8. D. Nasipuri, Stereochemistry of Organic Compounds, Second Ed., New Age International, 2005.
9. P. Sykes, A Guide Book to Mechanism in Organic Chemistry, Longman, 1985.

**SEMESTER-I**

Course Name - Organic Chemistry Practical-I

**Course Code - SBS CH 010105 C 0042**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To acquire experimental skills important for various separation and purification techniques, functional group identification and drying of organic solvents. To get an exposure to industrial oriented chemical processes.*

*At the end of this course, students will learn the various purification methods, chromatographic separation and identification of organic compounds, solvent drying and functional group detection in organic compounds. Students would be familiarized with manufacturing, designing and analysis of the organic compounds at commercial level.*

**UNIT 1: PURIFICATION AND SEPARATION TECHNIQUES: PRINCIPLE AND APPLICATION**

***Part A***

* Crystallization and recrystallization
* Sublimation
* Distillation: Simple, Steam and Vacuum
* Solvent Extraction
* Chromatography: Paper and Thin-layer

***Part B***

Chemical Tests: Chemistry and Application

* Extra elements detection (N, S, X = Cl, Br, I)
* Functional group detection (in mono functional compounds)

**UNIT 2:** **SOLVENT DRYING AND REFLUXING**

***Part A***

* Drying of ethanol/ acetone/ diethylether/THF
* Refluxing of water/ ethanol/toluene

***Part B***

Industrial visit- to relevant Industry and preparation of a short report.

#### Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition, Cengage Learning, 2017.
2. R. K. Bansal, Laboratory Manual in Organic Chemistry, Wiley, 2006.
3. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, Pearson, 2003.
4. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, Prentice Hall, Instructor's Edition, 1992.
5. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, Edward Arnold, London, 1975.
6. H. Middleton, Systematic Qualitative Organic Analysis, Edward Arnold, London, 1959.

**SEMESTER-II**

**Corse Name - Organic Chemistry-II**

**Course Code - SBS CH 010208 C 4004**

#### Credits: 4

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***Course Objective and Learning Outcomes:***

#### *To provide advance knowledge of organic chemistry reactions such as addition reactions, free radical, photochemistry and pericyclic reactions. At the end of this course, students will be trained in solving the problems related to addition reactions, free radical reactions, photochemistry and pericyclic reactions.*

#### UNIT I: ADDITION REACTIONS OF CARBON-CARBON AND CARBON-HETEROATOM MULTIPLE BONDS

***a) Polar addition to Carbon-Carbon Multiple Bonds:***

Mechanistic and stereochemical aspects of following **electrophilic addition reactions**: hydrohalogenation, hydration, epoxidation, Woodward and Prevost dihydroxylations, halogenation, halocyclizations, oxymercuration, hydrogenation, hydroboration and carbene cyclopropanation. General aspects of addition reactions of alkynes and allenes. Addition of **nucleophiles** to alkenes, Michael reaction, nucleophilic epoxidation and cyclopropanation.

***b) Addition to Carbon-Heteroatom Multiple Bonds:***

Reactivity of various carbonyl compounds, Mechanistic and stereochemical aspects of following nucleophilic addition reactions to carbonyl compounds**:** hydration, acetalization, imine and enamine formation,Grignard, organozinc and organolithium reagents, Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, Addition of ylides (Wittig, Julia and Peterson reactions), hydride reductions of various carbonyl compounds, Hydrolysis of acetals, esters, amides and nitriles.

#### UNIT II: FREE RADICAL REACTIONS AND ORGANIC PHOTOCHEMISTRY

***a) Free radicals:***Generation of free radicals, structure and stability, persistent radicals, common initiators and uses (peroxides, UV light, AIBN-tin hydride), radical anions and cations (One electron redox reactions), radical chain reactions, radical scavengers, Types of free radical reactions: substitution (halogenation, Sandmeyer reaction), addition (to unsaturated systems, radical cyclization), fragmentation (Hunsdiecker reaction), rearrangement, intramolecular H-abstraction (Hofmann-Loeffler and Barton reactions), oxidation (autooxidation of aldehydes) and dimerization (Pinacol, McMurry, acyloin and Glaser reactions)

***b) Organic Photochemistry*:** Fundamentals of organic photochemistry, Photochemical reactions of alkenes: photo-cycloaddition, Paterno-Buchi reaction, di-pi-methane rearrangement) Photochemical reactions of carbonyl compounds: Norrish type I and II reactions, oxa-di-pi methane rearrangement. Modern photoredox catalysis.

**UNIT III: PERICYCLIC REACTIONS I- ELECTROCYCLIC AND CYCLOADDITION REACTIONS**

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene, allyl and pentadienyl systems. Classification of pericyclic reactions. FMO approach. **Electrocyclic reactions**: conrotatory and disrotatory modes and effect on stereochemistry, 4n, 4n +2, allyl and pentadienyl systems, Nazarov cyclization. **Cycloaddition reactions:** antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, Detailed treatment of Diels-Alder reactions (types of Diels-Alder reactions, common dienes and dienophiles, endo/exo selectivity, catalysis, synthetic applications, intramolecular and hetero Diels-Alder reactions), **1,3-dipolar cycloadditions**: structure, methods of preparation andsynthetic applications of nitrones, nitrile oxides and azides.

**UNIT IV: PERICYCLIC REACTIONS II- SIGMATROPIC, ENE AND CHELOTROPIC REACTIONS**

**Sigmatropic rearrangements**: General considerations, suprafacial and antarafacial shifts of H and alkyl groups, 1,3, 1,5, 3,3 and 2,3-sigmatropic rearrangements. Valence tautomerism (divinyl cyclopropane and bullvalene), Detailed treatment of Claisen (Eschenmoser, Johnson, Ireland and aromatic variants), Cope (oxy-Cope and anionic oxy-Cope) rearrangements. Wittig, aza-Wittig and Sommelet-Hauser rearrangements, concerted syn-elminations. **Ene reactions**: General features, carbonyl and oxy-ene reactions, intramolecular ene reactions. **Chelotropic eliminations**: Definition, examples involving nitrogen, sulfur dioxide and carbon monoxide extrusions.

#### Suggested Readings:

1. S. Kumar, V. Kumar and S. P. Singh, Pericyclic Reactions, A Mechanistic and Problem Solving Approach, Ist Ed., Elsevier, 2015.
2. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Ed., WILEY, 2013.
3. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, Oxford University Press, 2012.
4. Morrison, Boyd and Bhattcharjee, Organic Chemistry, 7th Ed., Pearson, 2010.
5. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A and PART B, Springer 2007.
6. S. Sankararaman, Pericyclic reactions-A Textbook, 1st Ed., Wiley-VCH, Weinheim, 2005.
7. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanism, Harcourt (India) Pvt. Ltd., 2001.
8. P. Sykes, A Guide Book to Mechanism in Organic Chemistry, Longman, 1985.
9. S. M. Mukherji and S. P. Singh, Macmillan Reaction Mechanism in Organic Chemistry, 1984.
10. S. M. Mukherji, Pericyclic Reactions, Macmillan, India, 1980.

**SEMESTER-II**

Course Name - Organic Chemistry Practical-II

**Course Code - SBS CH 010211 C 0042**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To acquire experimental skills and hands on experience of various separation and purification techniques specifically applicable to binary mixtures, and identification of the given unknown organic compounds. To get hands on experience in synthetic organic chemistry and quantitative analysis.*

*At the end of this course, students will learn the various purification methods, chromatographic separation and identification of organic components present in the given binary mixtures. Further, they will learn about the various important parameters of organic synthesis preferably in greener approaches. Students would also be able to determine the number of some functional groups present in the given organic samples.*

**UNIT I: QUALITATIVE ANALYSIS OF THE GIVEN BINARY ORGANIC MIXTURE (***SOLID-SOLID* AND *SOLID-LIQUID* MIXTURES**) BY A SYSTEMATIC APPROACH**

Chemical separation: using H2O, NaHCO3, NaOH, HCl, Ether or any other reagent as per required conditions.

Systematic identification of the components and preparation of at least one derivative of each.

**UNIT II: ORGANIC SYNTHESIS AND QUANTITATIVE ANALYSIS**

Preparation of an organic compound involving one-step reaction. (Prepare at least three compounds)

[**Important *Note:*** *Prefer to use* ***greener protocols*** *wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC*]

Estimation of alcoholic/phenolic/amino groups in the given organic compound.

Determination of Iodine and Saponification values of an oil sample.

#### Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition, Cengage learning, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, CRC Press, First Edition, 2015.
3. R. K. Bansal, Laboratory Manual in Organic Chemistry, Wiley, 2006.
4. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5th Edition Paperback, Pearson, 2003.
5. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, Prentice Hall, Instructor's Edition, 1992.
6. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, Edward Arnold, London, 1975.
7. H. Middleton, Systematic Qualitative Organic Analysis, Edward Arnold, London, 1959.

**SEMESTER-III**

**Course Name - Applications of Spectroscopy**

**Course Code - SBS CH 010313 C 4004**

**Credits: 4**



***Course Objective and Learning Outcomes:***

### *To provide the advance knowledge and understanding of organic spectroscopy. At the end of this course, students will acquire both the theoretical and application aspect of various spectroscopic techniques (UV-Visible, IR, NMR spectroscopy and mass spectrometry) to the solve problems related to structure determination of organic compounds.*

### UNIT I: ULTRAVIOLET AND VISIBLE SPECTROSCOPY AND MASS SPECTROMETRY

***UV-Visible spectroscopy****:* Various electronic transitions, Beer-Lambert law, visible spectrum & colour, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.

***Mass spectrometry****:* Introduction, ion production–EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry (HRMS).

**UNIT II: INFRARED SPECTROSCOPY**

Instrumentation and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance.

**UNIT III: NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY**

General introduction and definition, theory of NMR, chemical shift, shielding and deshielding mechanism, magnetic anisotropy, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), spin-spin interaction, Spin systems, Pople notation, complex spin-spin interaction between two, three and four nuclei (first order spectra), virtual coupling. chemical exchange, effect of deuteration, Stereochemistry, hindred rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra, nuclear magnetic double resonance, contact shift reagents. Fourier transform technique, nuclear Overhauser effect (nOe), COSY.

**UNIT IV: CARBON-13 NMR SPECTROSCOPY AND COMBINED APPLICATIONS**

***Carbon-13 NMR Spectroscopy*:** General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroarmatic and carbonyl carbon), coupling constants and DEPT 13C NMR spectra. General introduction to two-dimensional NMR spectroscopy- HETCOR and NOESY. Resonance of other nuclei-F, P.

***Combined problems*:** Combined problems relating to structure elucidation by UV, IR, NMR Spectroscopy and Mass Spectrometry.

#### Suggested Readings:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th ed. Cengage India, 2015.
2. R. Kakkar, Atomic and Molecule Spectroscopy: Basic Concepts and Applications, Cambridge University Press, 2015.
3. W. Kemp, Organic Spectroscopy, Mac publishers, 3rd Ed., 2011.
4. D. H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata McGraw-Hill, 2010.
5. J. R. Dyer, Application of Spectroscopy of Organic Compounds, Prentice Hall, 2009.
6. R. J. Abraham, J. Fisher and P. Loftus, Introduction to NMR Spectroscopy, Wiley, 2005.
7. J. Mohan, Organic Spectroscopy, Narosa Publishers, New Delhi, 2002.
8. R. M. Silverstein, G. C. Bassler and T. C. TMorrill, Spectrometric Identification of Organic Compounds, John Wiley, 1995.
9. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th ed. Tata McGraw Hill, 1994.

**SEMESTER-III**

Course Name - Organic Chemistry-III (Heterocycles and Natural Products)

**Course Code - SBS CH 010304 SE 4004**

### Credits: 4

***Course Objective and Learning Outcomes:***

### *To provide the advance knowledge of heterocyclic and natural products chemistry. At the end of this course, students will learn about the synthesis, chemical transformation and reaction mechanism involved in Heterocyclic Chemistry. They will also gain knowledge about different class of natural product (synthesis and reactions) and its application and importance in drug discovery and development process.*

### UNIT I: HETEROCYCLIC CHEMISTRY-I

Introduction, Nomenclature, spectral characteristics, reactivity and aromaticity, Strain-bond angle and torsional strain and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction. Synthesis and reactions of three and four membered heterocycles (aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes). Synthesis and reactions of benzofused five membered heterocycles (benzopyrroles, benzofurans and benzothiophenes)

**UNIT II: HETEROCYCLIC CHEMISTRY-II**

Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrirylium salts and pyridones. Chemistry of bicyclic compounds containing one or more heteroatom. Benzofused six membered rings: synthesis and reactions of benzopyrans, quinolones, isoquinolines, acridines, benzotriazoles, quinolinizium and benzopyrylium salts. Seven and large membered heterocycles: azepines, oxepines, thiepines, Chemistry of porphyrins and spiroheterocycles.

**UNIT III: NATURAL PRODUCTS-I**

***Terpenoids and Carotenoids***

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Stereochemistry, Synthesis (chemical/biosynthesis) of the following representative molecules: Citral, α-Terpeneol, Farnesol, Santonin, Phytol and β-carotene.

***Steroids***

Occurrence, nomenclature, basic skeleton, Diel’s hydrocarbon and stereochemistry. Isolation and synthesis/biosynthesis of Cholesterol, Testorosterone, Progesterone, Oestrone.

**UNIT IV: NATURAL PRODUCTS-II**

***Alkaloids***

Definition, nomenclature, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring. Stereochemistry, synthesis and biosynthesis of the following: Ephedrine, Nicotine, Atropine and Quinine.

***Flavonoids***

Introduction, isolation and purification of flavonoids, General methods of structural determination of flavonoids, Biosynthesis of flavonols and related polyphenols. Structure and synthesis of apigenin, luteolin, quercetin and diadzen.

#### Suggested Readings:

1. B. A. Bohm, Introduction to Flavonoids, Harwood Academic Publishers, 2011.
2. I. L. Finar, Organic Chemistry, Vol. 2, ELBS., 2009
3. Atta-ur-Rahman and Choudhary, Chemistry, Harwood Academic Publishers, 2008.
4. E. S. Coffey, Rodd’s Chemistry of Carbon Compounds, Elsevier, 2005
5. J. A. Joule, Heterocyclic Chemistry, ELBS, 2005
6. Mann, Davidson, Hobbs, Banthrope and Harborne, Natural products: Chemistry and Biological Significance, Longman, Essex., 2004.
7. T. Eicher and S. Hauptmann, The Chemistry of Heterocycles, Thieme, 2002.
8. G. R. Newkome and W. W. Paudler, Contemporary Heterocyclic Chemistry, Wiley-Interscience, 1995.
9. T. L. Gilchrist, Heterocyclic Chemistry, Longman Scientific Technical, 1990.
10. R. M. Acheson, An Introduction to Heterocyclic Chemistry, John Wiley, 1980
11. A. R. Katritzky and C. W. Rees, Comprehensive Heterocyclic Chemistry, eds. Pergamon Press, 1970.

**SEMESTER - III**

Course Name - Organic Chemistry IV (Reagents and Reactions)

**Course Code - SBS CH 010305 SE 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide the advance knowledge of organic synthesis in general and classical and modern reagents and methods in synthesis in particular. In-depth knowledge of metal-mediated reactions and common metal-based reagents, oxidation-reduction reactions and reagents and rearrangement reactions will be gained. At the end of the course students are expected to predict reagents and conditions needed for specific conversions.*

**UNIT I: USE OF METALS IN ORGANIC SYNTHESIS**

Alkali metal reagents (LDA, LHMDS, KHMDS); organomagnesium compounds, Reactions with carbonyl compounds; Stereoselectivity of additions to ketones, olefination reactions and reagents (Wittig, Wadsworth, Peterson, Julia and McMurry reactions); Amide coupling reagents (DCC, DIC, EDC, BOP, HOBt, Mukiyama reagent); Mitsunobu reaction; Palladium mediated reaction: Wacker process, Heck reaction, Suzuki coupling, Negishi coupling, Kumada coupling, Sonagashira reaction and Buchwald-Hartwig amination.

**UNIT II: OXIDATION REACTIONS**

Common oxidizing agents (transition metal oxidant, sulphur based, peroxide and peracid, modern catalytic oxidations) for oxidation of alcohols, ketones and aldehydes; Oxidation of C-C bonds [ozone, KMnO4, Pb(OAc)4, dimethyldioxirane, Ce(IV) and Mn(III)] and saturated carbons; Woodward and Prevost dihydroxylation, hypervalent iodine reagents, DDQ.

**UNIT III: REDUCTION REACTIONS**

Common reducing agents such as dissolving metal reductions (Birch reduction), various Aluminum and Boron derived hydrides, catalytic/transfer hydrogenations (Homogeneous and Heterogeneous), diimide, Bu3SnH, low valent Ti species, microbial reductions (NADH models) and Wolf-Kishner reduction.

Asymmetric reduction using Corey’s oxazaborolidine (CBS catalyst) and Noyori’s hydrogenation.

**UNIT IV: REARRANGEMENT REACTIONS**

General mechanistic considerations, nature of migration, migratory aptitude and mechanistic study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwin, Benzil-Benzilic acid, Favorskii, Arndt-Ester synthesis, Demyanov, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction, Dienone-Phenol, Claisen, Cope, Von-Ritcher, Pummerer, Smiles and Sommelet-Hauser rearrangements.

#### Suggested Readings:

1. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, 5thed. Springer Verlag, 2012.
2. V. K. Ahluwalia, Oxidation in Organic Synthesis, CRC press, 2012.
3. J. H. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, University Science Books, 1st Ed. 2009.
4. L. Kurti and B. Czako, Strategic Applications of Name Reactions in Organic Synthesis, Elsevier Academic Press 2005.
5. R. H. Crabtree, The Organometallic chemistry of the transition metals, John Wiley, 2005.
6. W. Carruthers and Iain Coldham, Modern Methods of Organic Chemistry, 4th ed. Cambridge University Press, 2004.
7. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2nd ed. Oxford University Press, 2001.
8. J. March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure, 4th ed. John-wiley, 1999.
9. S. Warren, Organic Synthesis, Wiley, 1982.
10. H. O. House, W. A. Benjamin, Modern Organic Synthesis, Inc., New York, 1965.

**SEMESTER - III**

Course Name - Organic Chemistry Practical-III

**Course Code - SBS CH 010306 SE 0084**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To acquire hands on experience in organic synthesis particularly involving multistep reactions and to gain knowledge about quantitative analysis of organic compounds by spectroscopic methods. To get hands on experience in extraction and isolation of natural products.*

*At the end of this course, students will understand and acquire the knowledge of various important parameters used in multistep organic synthesis preferably in greener approaches. Further, they would be able to characterize the synthesized compounds on the basis of their spectral data. Students would also learn the spectrophotometric methods used for quantitative analysis of organic compounds besides having hands on experience in extraction and isolation of natural products.*

**UNIT I: MULTI-STEP ORGANIC SYNTHESIS**

Prepare at least any two organic compounds by three or more step reaction.

[**Important *Note:*** *Prefer to use* ***greener protocols*** *wherever possible. Monitor the progress of reaction by TLC and submit the recrystallised sample of the synthesized compound after checking its purity by TLC at each step*]

**UNIT II: SPECTROSCOPIC IDENTIFICATION OF ORGANIC COMPOUNDS**

Establish the chemical structure of the organic compounds with the help of their given UV-vis, IR and PMR spectral data.

**UNIT III: EXTRACTION OF NATURAL PRODUCTS**

* Caffeine from tea leaves
* β-Carotene from carrot
* Nicotine from tobacco
* Lactose from milk
* Casein from milk
* Limonene from citrus rind
* Piperine from black pepper
* Lycopene from tomatoes

**UNIT IV: QUANTITATIVE ANALYSIS**

UV-vis spectrophotometric estimations of the followings:

* Carbohydrates
* Ascorbic acid
* Amino acids
* Proteins
* Cholesterol
* Urea
* Aspirin

#### Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition, Cengage learning, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, CRC Press, First Edition, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th ed. Cengage India, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. TMorrill, Spectrometric Identification of Organic Compounds, 8th Edition, Wiley India, 2015.
5. William Kemp, Organic Spectroscopy, Mac publishers, 3rd Edition, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, Wiley, 2006.
7. Jag Mohan, Organic Spectroscopy, CRC Press, 2nd Edition, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, Pearson, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, Prentice Hall, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, Edward Arnold, London, 1975.
11. H. Middleton, Systematic Qualitative Organic Analysis, Edward Arnold, London, 1959.

**SEMESTER-IV**

Course Name - Organic Chemistry-V (Organic Synthesis)

**Course Code - SBS CH 010412 SE 4004**

### Credits: 4



***Course Objective and Learning Outcomes:***

*To gain an in-depth understanding of various functional group transformations, classical and modern techniques in synthetic chemistry, synthetic planning and targeted synthesis of complex molecules. Detailed information and analysis of common synthetic techniques and methods will be gained.   Using this knowledge, exercises on the planning of synthesis of complex scaffolds and targets will be carried out. Breakdown of complex molecules into simple building blocks for synthesis will be learned. A few case studies of total synthesis to understand the actual application of synthetic methods in real life problem solving will also be learned. Students are expected to design retrosynthesis and forward synthesis of complex targets at the end of the course.*

### UNIT I: FUNCTIONAL GROUP TRANSFORMATIONS USING MISCELLANEOUS REAGENTS

Use of SOCl2, (COCl)2, PBr3, BBr3,PPh3-CX4, LiBr, NaI, NBS, PPh3-X2, Lawesson’s reagent, CH2N2, TMSCHN2, Achmatowicz reaction, Barbier-Weiland degradation, Chugaev elimination, Finkelstein reaction, Eschenmoser-Tanabe, Ohira-Bestmann reagent.

**UNIT II: CLASSICAL AND MODERN METHODS IN SYNTHESIS**

Strategies and tactics in total synthesis, overall yield, ideal synthesis, multicomponent reactions (Strecker, Mannich, Passerini and Ugi reactions), cascade and domino reactions, multiple C-C bond forming reactions, CH-activation, asymmetric organocatalysis (proline, NHCs), click chemistry, protecting group free synthesis, green chemistry, biotransfromations, Artificial enzymes in organic synthesis, Reusable reagents, biomimetic synthesis (polyene cyclizations), modern carbonyl chemistry (boron-aldol, modern olefinations).

**UNIT III: RETROSYNTHESIS AND DISCONNECTION APPROACH**

Concept of retrosynthesis, disconnection approach, introduction to synthons and synthetic equivalents, linear and convergent synthesis, types of transforms, functional group inter-conversions, classification of disconnections, chemoselectivity, control of stereochemistry, reversal of polarity (umploung), common building blocks, the importance of the order of events in organic synthesis, applications of alkynes, aliphatic nitro compounds, bifunctional compounds, Protecting groups, representative examples for O, N, COOH and carbonyl protection/deprotections.

**UNIT IV: CASE STUDIES- TOTAL SYNTHESIS**

Detailed case study of the following classical and modern total syntheses: Periplanone B (W. C. Still), Cubane (Pettit), Quinine (G. Stork).

#### Suggested Readings:

1. S. Warren, Designing Organic Synthesis, Wiley, 2011.
2. F. A. Carey and R. J. Sandburg, Advanced Organic Chemistry Part B, Plenum Press, 2009.
3. T. Hudlický and J. W. Reed, The Way of Synthesis, Wiley VCH-Weinheim 2007.
4. J. March, Advanced Organic Chemistry, Reactions Mechanisms and Structure, John Wiley, 2005.
5. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, Blackie Academic & Professional, 2002.
6. Fhrhop and Penzillin, Organic Synthesis-concept, Methods and Starting Materials, Verlage VCH, 1997.
7. K. C. Nicolaou and E. J. Sorensen, Classics in Total Synthesis, Wiley VCH-Weinheim, 1996.
8. W. Carruthers, Some Modern Methods of Organic Synthesis, Foundation Books, 1995.
9. Fieser and Fieser, Reagents in Organic Synthesis, Wiley, 1993.
10. H. O. House, W.A. Benjamin, Modern Synthetic Reactions, 1990.

**SEMESTER–IV**

Course Name - Organic Chemistry-VI (Medicinal Chemistry)

**Course Code - SBS CH 010413 SE 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*This course will provide a basic understanding and fundamentals of Medicinal Chemistry. At the end of this course, students will learn about the various stages involved in drug discovery & development process and challenges encounter during the course of development of new drug which finally comes into the market, various biological drug targets, drug-target binding, mode of actions of anticancer, antibiotics, psychoactive drugs and its chemical synthesis.*

#### UNIT I: DRUG TARGETS

#### Introduction to medicinal chemistry, intermolecular binding forces, Introduction to various drug targets; Proteins- primary, secondary and tertiary structure, protein function, proteomics; Enzymes- catalytic role, active site, allosteric binding, feedback control, binding interactions, isozymes, co-factors; Receptors- types of receptors, their roles, neurotransmitters, hormones, receptor activation and regulation; Nucleic acids- DNA, primary and secondary structure of DNA, function of DNA, molecular biology and genetic engineering.

#### UNIT II: DRUG-TARGET BINDING

#### Introduction to Pharmacodynamics and pharmacokinetics, Enzymes as drug targets- types of enzyme inhibitors, medicinal use of enzyme inhibitors with examples; Receptors as drug targets- agonists, antagonists, allosteric modulators, partial agonists, inverse agonists, desensitization, tolerance and dependence, affinity and efficacy; Nucleic acids as drug targets- Intercalating agents, topoisomersae poisons, alkylating/metallating agents, chain cutters, chain terminators, examples of medicinal use. Miscellaneous drug targets (tubulin)

#### UNIT III: DRUG DESIGN AND DEVELOPMENT

#### Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism. Theories of drug activity, Quantitative structure activity relationship, Concepts of drugs receptor, Elementary treatment of drug receptor interactions, Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric factors.

#### UNIT IV: MODE OF ACTION AND SYNTHESIS

#### *Anticancer Agents:* Antineoplastic Agents, cancer chemotherapy, common targets in cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Synthesis of any three representative anticancer drugs.

***Antiinfective Drugs (antibiotics)****:* Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, amoxycillin, cephalosporin, ciprofloxacin. Introductory idea of tetracycline and streptomycin.

***Psychoactive Drugs***: Introduction and general mode of action. CNS depressants, general anaesthgetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, Synthesis of any two representative psychoactive drugs.

#### Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Ed., Academic Press, 2014.
2. J. J. Li, Name Reactions, 5th ed. Springer, 2013.
3. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Ed., Oxford University Press, 2013.
4. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, 5th ed. Springer Verlag, 2012.
5. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2nd ed., Pearson, 2012.
6. Ed Robert F Dorge, Wilson and Gisvold’s Text Book of Organic Medicinal and Pharmaceutical Chemistry, 12th Ed., 2010.
7. Ed. M E Wolff, Burger’s Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Ed., John Wiley, 2010
8. J. H. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, University Science Books, 1st Ed. 2009.
9. P. Knochel, Handbook of Functionalized Organometallics, Volume 1 and 2, Wiley-VCH, 2005.
10. R. H. Crabtree, The Organometallic chemistry of the transition metals, John Wiley, 2005.
11. W. Carruthers and Iain Coldham, Modern Methods of Organic Chemistry, 4th ed. Cambridge University Press, 2004.
12. S. Warren, N. Greeves, J. Clayden and P. Wothers, Organic Chemistry, 2nd ed. Oxford University Press, 2001.
13. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Ed., New Age International, 1999.
14. R. Norman, J. M. Coxon, Principles of Organic Synthesis, 3rd ed. Chapman & Hall, 1993.

**PHYSICAL CHEMISTRY COURSES**

SEMESTER-I

Course Name - Physical Chemistry-I (Introduction to Physical Chemistry)

**Course Code - SBS CH 010103 C 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide students with a basic understanding of physical chemistry, classical thermodynamics, activity, fugacity, phase rule, essentials of chemical kinetics and principle of quantum mechanics. This course will strengthen the fundamentals of Physical Chemistry, especially thermodynamics and quantum chemistry.*

**UNIT I: INTRODUCTION TO PHYSICAL CHEMISTRY AND CLASSICAL THERMODYNAMICS**

Logarithmic relations, Curve sketching and linear graphs, calculation of slopes, terms of mean and median, Precision and accuracy in chemical analysis, types of error, standard deviation, Numerical Problems. Classical Thermodynamics & its Laws, Maxwell’s relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities like entropy, enthalpy, free energy; Gibb`s-Duhem equation; Clausius-Clapyeron equation,Nernst heat theorem,Chemical potential and Work Function.

**UNIT II: ACTIVITY, FUGACITY, PHASE RULE**

Concepts of fugacity, fugacity of gases and its determination. Activity and activity coefficient, choice of standard states, determination of activity coefficient for solute and solvent. Phase Rule and its determination, application, Phase diagram for one component system, for two completely miscible components systems like Pb-Ag system, KI+ H2O system, Bi-Cd system, Ferric chloride + water system, Sodium chloride + water system, Na2SO4-H2O system.

**UNIT III: CHEMICAL KINETICS-I**

***Introduction to Chemical Kinetics*:** Methods of determining rate laws, Arrhenius equation and its theory, Collision theory, and activated complex theory.

***Chain Reactions*:** Hydrogen-bromine reaction, Pyrolysis of acetaldehyde, Decompositions of ethane. Photochemical reactions (hydrogen-bromine and hydrogen-chlorine reactions). General treatment of chain reaction (hydrogen- bromine reactions), Apparent activation energy of chain reactions, Chain length, Rice-Herzfeld mechanism of organic molecules decomposition (acetaldehyde).

**UNIT IV: PRINCIPLES OF QUANTUM MECHANICS**

Introduction to Quantum Mechanical Approach, Quantum Mechanical operators, Eigenvalues of Quantum Mechanical operators, Hermitian operator, commutation relations, postulates of quantum mechanics and Uncertainty Principle. Schrödinger equation for finding wave function of a particle, Energy of a particle in One-Dimension box, Extension to Schrödinger equation for finding wave function in a three-dimensional box, Energy of a particle in Three-Dimension box, Energy levels, Eigenvalue, degeneracy and selection rules.

#### Suggested Readings:

1. H. K. Moudgil, Textbook of Physical Chemistry, PHI Publication House, New Delhi, 2015.
2. Peter Atkins and Julio Paula, Atkins' Physical Chemistry, Oxford University Press; 10th ed., 2014
3. I. N. Levine, Quantum Chemistry, Pearson Education, 7th Ed., 2013.
4. Ira N. Levine, Physical Chemistry, Tata Mcgraw-Hill Education, 6th ed., 2011.Donald Mcquarie and John Simon, Physical Chemistry-A molecular approach, Viva, 1st ed., 2010.
5. R. K. Prasad, Quantum Chemistry, New Age International, 2001.
6. A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill, 1998.
7. Keith J. Laidler, Chemical Kinetics, Pearson Education, 3rd ed., 1997.

SEMESTER-I

Course Name - Physical Chemistry Practical-I

**Course Code - SBS CH 010106 C 0042**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To train students with introductory physical chemistry practicals like adsorption, saponification value, molecular weight determination, surface tension, viscosity, distribution law and thermochemistry.*

*At the end of the course students will have first-hand experience of performing simple physical chemistry experiments independently.*

**UNIT I:** (**Hands on training in Physical Chemistry Experiments)**

*Partial Molar Quantities*

* To determine the partial molal volume of urea in aqueous solution from density measurements.
* To determine the partial molar volume of ethanol-water mixture at a given composition.

*Adsorption*

* To determine the adsorption isotherms of acetic acid from aqueous solution by charcoal.
* To study the adsorption of I2 from alcoholic solution by charcoal.
* To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal and to examine the validity of Freundlich & Langmuir’s adsorption isotherms.

*Acid and Saponification Value*

* To find out the acid value of a given sample.
* To find out the saponification value of given vegetable oil.
* To determine the viscosity of highly viscous liquid.

*Molecular Weight of Polymer*

* To determine the molecular weight of a given polymeric solution by viscosity method.
* To determine the molecular weight of a given substance i.e. naphthalene and biphenyl by Rast method.

**UNIT – II** (**Basics Physical Chemistry Experiments**)

*Surface Tension/Interfacial Tension*

* To find surface tension/interfacial tension between two immiscible liquids.
* To determine surface tension of given liquid like CCl4 by number drop method using stalganometer.
* To determine the percentage composition of a given mixture of two liquids say CCl4 and Toluene by surface tension method.

Viscosity

* To find viscosity of unknown liquids by Ostwald’s viscometer method.
* To determine the percentage composition of given unknown mixture by viscosity method.
* To determine the coefficient of viscosity of a liquid such as ethyl acetate with the help of Ostwald viscometer.

*Distribution Law*

* To study the distribution of benzoic acid between benzene and water at room temperature and show that benzoic acid dimerizes in benzene.
* To determine the distribution coefficient of I2 between organic liquid and water at a given temperature.
* Study of distribution coefficient of succinic acid between organic liquid and H2O at a given temp.

Thermochemistry

* To determine the heat of neutralization of sulphuric acid using Dewar’s vacuum flask as the calorimeter.
* To determine the heat of ionization of a weak base i.e. NH4OH using calorimeter.

*(Note: Depending on availability of time and equipment’s, some experiments may be added/deleted during the semester).*

#### Suggested Readings:

1. Senior Practical Physical Chemistry, B. D. Khosla, V. C. Garg, Adarsh Gulati, R. Chand & Co., New Delhi, 2014
2. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh, New Central book Agency, 2012.
3. Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan, M V Learning, 2010.
4. Experiments in Physical Chemistry, Shoemaker and Garland, McGraw Hill, 2005.
5. Experimental Physical Chemistry, R. C. Das, B. Behara, Tata McGraw Hill, 1984.
6. Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House, 1981.
7. Practical Physical Chemistry, A. M. James, F. E. Prichard, Lomgman, 1974.
8. B. P. Levitt, Findley’s Practical Physical Chemistry, 9th ed. Longman Group Ltd., 1973.

**SEMESTER-II**

Course Name - Physical Chemistry-II (Quantum Chemistry & Group Theory)

**Course Code - SBS CH 010209 C 4004**

**Credits: 4** 

***Course Objective and Learning Outcomes:***

*To provide students with an understanding of physical chemistry like quantum approach, enzyme kinetics, unimolecular reactions, principles of symmetry and group theory and non-equilibrium thermodynamics. This course will strengthen the essentials of Physical Chemistry, especially group theory and quantum chemistry.*

**UNIT I: QUANTUM APPROACH AND APPROXIMATION METHODS**

***Harmonic oscillator*:** Application to diatomic molecules and Energy levels.

***Rigid rotator*:** Model for a rotating diatomic molecule and Energy level.

***The Hydrogen atom*:** Schrödinger equation for hydrogen atom and shapes of atomic orbitals.

***Approximate Methods*:** The linear variation principle, Perturbation theory (first order and non-degenerate).

**UNIT II: ENZYME KINETICS AND THEORY OF UNIMOLECULAR REACTIONS**

***Enzyme Kinetics*:** Kinetics of (one intermediate) enzymatic reaction: Michaelis-Menton treatment, Evaluation of Michaelis’s constant for enzyme-substrate binding by line weaver-Burk plot by Dixon and by Eadie-Hofstee methods. Competitive and non-competitive inhibition.

***Unimolecular reactions*:** Dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions.

**UNIT III: PRINCIPLES OF SYMMETRY AND GROUP THEORY**

Symmetry elements and Symmetry operations; Definitions of groups, subgroups, and classes; Symmetry elements in Allene, H2O2, Benzene and Ferrocene; Determination of point groups of small molecules and Schönfliesand Hermann-Mauguin Notations; The Great Orthogonality theorem. Character table for point group Cn (C2v and C3v), Dn, (n=2 and 3), Td and Oh.

**UNIT IV: NON EQUILIBRIUM THERMODYNAMICS**

General theory of non-equilibrium processes, Entropy production and entropy flow; Thermodynamic criteria for non-equilibrium states, Entropy production in heat flow, Mass flow, Electric current, Chemical reactions, Saxen`s relation, Onsager’s reciprocity relation, Thermomolecular pressure difference, Electrokinetic phenomenon, Coupled reactions.

#### Suggested Readings:

1. H. K. Moudgil, Textbook of Physical Chemistry, PHI Publication House, New Delhi, 2015.
2. P. Atkins and J. Paula, Atkins' Physical Chemistry, Oxford University Press; 10th ed., 2014.
3. I. N. Levine, Quantum Chemistry, Pearson Education, 7th Ed., 2013.
4. F. A. Cotton, Chemical Application of Group Theory, John Willey & Sons, 3rd Ed., 2008.
5. C. Kalidas and M. V. Sangaranarayanan, Non-Equilibrium Thermodynamics: Principles & Applications, Macmillan India Ltd., 2002.
6. R. K. Prasad, Quantum Chemistry, New Age International, 2001.
7. A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill, 1998.
8. K. J. Laidler, Chemical Kinetics, Pearson Education, 3rd ed., 1997.
9. G. Davidson, Group theory for Chemist, Macmillan Physical Science, 1991.
10. A. Katchalsky and P. F. Curren, Non Equilibrium Thermodynamics in Biophysics*,* Harvard University Press: Cambridge, 1965.

SEMESTER - II

Course Name - Physical Chemistry Practical-II

**Course Code - SBS CH 010212 C 0042**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To provide students exposure of refractometry, chemical kinetics, solution chemistry, turbidity metry, and pH, potentio and conductometry experiments. Advanced experiments such as pH metry, potentiometry and conductometry will be carried out. First-hand experience of turbidity meter studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*

**UNIT I: CHEMICAL KINETICS AND PH METRY EXPERIMENTS**

*Refractometry*

* Variation of refractive index with composition for a mixture of two organic liquids.
* To determine the molar refractivity of CH3OH, CH3COOH, CH3COOC2H5 and CCl4 and calculate the refractive equivalent of C, H and Cl atoms.
* Find out molar refractivity of benzene, toluene, propyl alcohol, butyl alcohol *etc*. and –CH2- group of homologous series.

*Chemical Kinetics*

* Determination of the effect of (a) change in temperature, (b) change in concentration of reactants and catalysts (c) ionic strength of the media on velocity constant of hydrolysis of an ester.
* Determination of the rate constant of an ester catalyzed by an acid.
* Determine the velocity constant of hydrolysis of ethyl acetate using sodium hydroxide solution.

*Solution Chemistry*

* To determine the solubility of an inorganic salt like KCl, NaCl, KNO3, NaNO3, K2SO4 etc. in water at different temperature and hence to obtain the solubility curve.
* To determine the heat of solution of given substance like oxalic acid and benzoic acid by solubility method.

*pH Metery*

* To determine the strength of strong acid versus strong base, weak acid versus strong base, mixture of strong and weak acids versus strong base, weak acid versus weak base, strong acid versus weak base using a pH meter.
* To determine the concentration of a reductant or an oxidant i.e. Ferrous ammonium sulphate, K2Cr2O7and KMnO4 by a pH meteric titration method.
* To determine the amount of KI and KCl present in a mixture by using pH meter.
* To determine the strength of polybasic acid (H3PO4 and oxalic acid) with the help of pH meter.

**UNIT II: POTENTIOMETRY AND CONDUCTOMETRY EXPERIMENTS**

*Potentiometery*

* To determine the strength of strong acid versus strong base, weak acid versus strong base, mixture of strong and weak acids versus strong base, weak acid versus weak base, strong acid versus weak base using a potentiometer.
* To prepare and test the standard reference electrode i.e. calomel electrode or silver- silver chloride electrode.
* Titrate Mohr’s salt against KMnO4potentiometrically and carry out the titration in reverse order.

*Turbiditymetry*

* To find the turbidity of given solution by using Nephthalo turbidity meter.

*Conductometry*

* Study of conductometric titration of NH4Cl versus NaOH solution and comment on the nature of graph.
* Study of conductometric titration of CH3COONa versus HCl and comment on the nature of graph.
* Study conductometric titration of MgSO4 versus Ba(OH)2 and comment on the nature of the graph.
* Study conductometric titration of BaCl2 and K2SO4 and comment on the nature of graph.
* To study stepwise neutralization of polybasic acid *i.e*. oxalic acid, citric acid, succinic acid, phosphoric acid by conductometric titration and explain the variation in the graph.
* To determine the relative strength of two acid mixtures (strong and weak acid) using conductometer.

*(Note: Depending on availability of time and equipment’s, some experiments may be added/deleted during the semester).*

#### Suggested Readings:

1. B. D. Khosla, V. C. Garg, Adarsh Gulati, Senior Practical Physical Chemistry, R. Chand & Co., New Delhi, 2014.
2. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central book Agency, 2012.
3. Shoemaker and Gailand, Experiments in Physical Chemistry, McGraw Hill, 2005.
4. R. C. Das and B. Behara, Experimental Physical Chemistry, Tata McGraw Hill, 1984.
5. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 1981.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, Lomgman, 1974.
7. B. P. Levitt, Findley’s Practical Physical Chemistry, 9th ed. Longman Group Ltd., 1973.

**SEMESTER-III**

Course Name - Molecular Spectroscopy

**Course Code - SBS CH 010314 C 4004**

**Credits: 4**



***Course Objective and Learning Outcomes:***

*To provide students with an understanding of the basics of molecular spectroscopy like rotational, vibrational, Raman, electronic and solid state and surface spectroscopy. This course will strengthen the essentials of molecular spectroscopy, especially microwave and infrared spectroscopy.*

**UNIT I: ROTATIONAL SPECTROSCOPY**

***Basics of Molecular Spectroscopy***

Electromagnetic radiation and its region, representation of spectra, signal to noise ratio, resolving power, width and intensity of spectral lines.

***Rotational (Microwave) Spectroscopy***

Rotational Spectroscopy-Rigid diatomic Rotator, Selection rule for rotational/microwave spectrum, determination of bond-length, intensity of spectral lines, effects of isotopes on rotational spectra, Non-rigid rotator, Stark effect, Rotational spectra of linear polyatomic molecules, Application of microwave spectroscopy.

**UNIT II: VIBRATIONAL AND RAMAN SPECTROSCOPY**

***Infrared (Vibrational) Spectroscopy***

Vibration in Diatomic molecules, Simple Harmonic OscillatorModel,Anharmonic Oscillator, Selection Rule, Population of VibrationalEnergy level, Diatomic Vibrating Rotator, P-Q-R Branches of Spectra, Breakdown of Born Oppenheimer Approximation, Fundamental Vibration and their Symmetry, Overtone andCombination frequency, Applications of Infra-red spectroscopy.

***Raman Spectroscopy***

Stokes and anti-Stokes lines.Polarizability ellipsoids.Pure Rotational Raman spectra, pure vibrational Raman spectra.Selection rules.Rule of Mutual Exclusion.Polarization of light, Raman Effect, Application of Raman and Infra-red spectroscopy in structure determination.

**UNIT III: ELECTRONIC SPECTROSCOPY**

Principle of electronic spectroscopy, Total electronic angular momentum, Term symbol.Vibrational Coarse Structure: Progressions, Franck-Condon Principle, Dissociation energy and dissociation products, Rotational fine structure of electronic-vibration transitions, Fortrat diagram, Pre-dissociation.

**UNIT IV: SOLID STATE AND SURFACE SPECTROSCOPY**

Electronic Energy loss Spectroscopy (EELS), Reflection-Absorption Infrared Spectroscopy (RAIRS), Photoelectron spectroscopy (PES): X-ray PES and Ultra-violet PES, Auger Electron Spectroscopy (AES) and X-ray Fluorescence (XRF).

##### **Suggested Readings:**

1. C. N. Banwell and E. M. McCash, Fundamental of Molecular Spectroscopy, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th ed., 2017.
2. D. N. Satyanarayana, Handbook of Molecular Spectroscopy: From radio waves to gamma rays, I. K. International Publishing House, New Delhi, 2015.
3. R. Kakkar, Atomic & Molecular Spectroscopy*,* Cambridge University Press, 2015.
4. J. M. Hollas, Modern Spectroscopy4th Ed., John Wiley & Sons, 2004.
5. B. E. Warren, X-Ray Diffraction*,* Dover Publications, 1990.
6. G. E. Bacon, Fifty Years of Neutron Diffraction*,* Hilger, 1987.
7. J. C. D. Brand and J. C. Speakman, Molecular Structure: The Physical Approach,2nd Ed., Edward Arnold: London 1975.
8. W. J. Moore, Physical Chemistry, 4th Ed. Prentice-Hall, 1972.
9. R. Chang, Basic Principles of Spectroscopy,McGraw-Hill, New York, N.Y., 1970.

SEMESTER-III

Course Name - Physical Chemistry-III (Statistical Mechanics, Surface and Interface Chemistry)

**Course Code - SBS CH 010307 SE 4004**

**Credits: 4**



***Course Objective and Learning Outcomes:***

*To provide students with an understanding of advanced physical chemistry like statistical mechanics and thermodynamics, surface chemistry and electrified interface. This course will strengthen the essentials of Physical Chemistry, statistical mechanics and surface chemistry.*

**UNIT I: STATISTICAL MECHANICS**

Concept of distribution, Thermodynamic probability and most probable distribution, Canonical, grand canonical and micro canonical ensembles. Maxwell-Boltzmann statistics, Boltzmann distribution, Derivation of the Boltzmann distribution expression, Determination of the Boltzmann constant, Maxwell distribution law of velocity from Boltzmann distribution expression, The Bose-Einstein statistics, Statistics of a photon gas, Fermi-Dirac statistics and comparison of three statistics.

**UNIT II: STATISTICAL THERMODYNAMICS**

Partition function and thermodynamic properties, Factorization of partition function, Relationship of partition function to thermodynamic properties, Translational partition function, Calculation of absolute entropy of an ideal monoatomic gas, Secure-Tetrode equation. Vibrational and rotational partition function of diatomic molecules. Calculation of contribution of vibrational, rotational partition functions towards various thermodynamic properties. Electronic partition function, Effect of change of zero point energy on partition function. Chemical equilibrium and equilibrium constant in terms of partition functions.

**UNIT III: SURFACE CHEMISTRY**

The extent of adsorption: Physical and Chemisorptions, Adsorption isotherms, Rates of surface processes (adsorption, desorption and mobility on surfaces). BET equation.

Heterogeneous catalysis: Mechanism of heterogeneous catalysis; Langmuir–Hinshelwood mechanism.

**UNIT IV: ELECTRIFIED INTERFACES**

Thermodynamics of electrified interfaces, Electrocapillary thermodynamics, Non-polarizable interface and Thermodynamic equilibrium. Fundamental thermodynamic equation of polarizable interfaces. Determination of excess charge density on the electrode, electrical capacitance and surface excess of the interface, potential of zero charge, Helmholtz-Perrin model, Gouy-Chapman model, Stern and Devanathan model.

#### Suggested Readings:

1. B. Bagchi, Statistical Mechanics for Chemistry and Material Science, CRC Press, 2018.
2. R. K. Pathria and Paul D. Beal, Statistical Mechanics, Elsevier III ed., 2016.
3. P. Atkins and J. P. Atkins' Physical Chemistry, Oxford University Press; 10th ed., 2014.
4. D. McQuarie and J. Simon, Physical Chemistry-A molecular approach, Viva, 1st ed., 2010.
5. Terrell L. Hill, An Introduction to Statistical Thermodynamics, Dover Publication, 2008.
6. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed., 2005.
7. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-1 (Ionics), Springer, 2006.
8. D. A. McQuarrie, Statistical Mechanics, Viva Books Pvt. Ltd., New Delhi, 2003.

SEMESTER - III

Course Name - Physical Chemistry-IV (Solid State Chemistry & Electro-Analytical Methods)

**Course Code - SBS CH 010308 SE 4004**

**Credits: 4**



***Course Objective and Learning Outcomes:***

*To provide students with an understanding of advanced physical chemistry like electrochemistry, electroanalytical and potentiometric methods and solid state chemistry. This course will strengthen the fundamentals of Physical Chemistry, especially electrochemistry and solid state chemistry.*

**UNIT I: ELECTROCHEMISTRY-II**

Contact adsorption on the electrode, Free energy of contact adsorption, The degree of contact adsorption and the measurement of contact adsorption, The influence of the contact adsorption on the capacity of the interface, Capacity-potential curve, The position of the OHP and the constant capacity, The capacitance hump, Variation of the population of contact-adsorbed ions with electrode charge, The lateral-repulsion model and the water Flip-Flop model of contact adsorption, The contribution of adsorbed water dipoles to the capacity of the interface.

**UNIT II: ELECTRO-ANALYTICAL & POTENTIOMETRIC METHODS**

Electrode potentials. Polarization (overvoltage) phenomenon and its theories, Description of standard hydrogen electrode, Measurement of potentials, Effect of concentration on cell potential. Concept of Liquid Junction potential. Ohmic potential (IR drop), Reference electrodes (Calomel, Ag/AgCl, Tl/TlCl) Metallic Redox indicator electrode: Membrane and ion selective electrodes: Principle and design. Glass electrode, Gas sensing probes. Enzyme electrode. Principle and applications of potentiometric methods.

**UNIT III: SOLID STATE CHEMISTRY-I**

Thermal decomposition reactions, Nucleation, Free energy of nucleation: Laws, Classification, Functions and growth of nuclei. Kinetic expressions for diffusion controlled, phase boundary controlled and nucleation and growth controlled reactions. Perfect and imperfect crystals, Intrinsic and extrinsic defects, Point defects, Line and plane defects, Vacancies: Schottky and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, Colour centres, non-stoichiometric defects.

**UNIT IV: SOLID STATE CHEMISTRY-II**

Classification of solids, Lattice energy, Evaluation of Madelung constant (NaCl), Calculation of repulsive potential exponent: Lattice heat capacity. Einstein and Debye model of lattice heat capacity, Debye T3 law.

#### Suggested Readings:

1. H. K. Moudgil, Textbook of Physical Chemistry, PHI Publication House, New Delhi, 2015.
2. P. Atkins and J. Paula, Atkins' Physical Chemistry, Oxford University Press, 10th ed., 2014.
3. D. Mcquarie and J. Simon, Physical Chemistry-A Molecular Approach, Viva, 1st ed., 2010.
4. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry 1 (Ionics), Springer, 2006.
5. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry II, Springer, 2006.
6. L. E. Smart, E. A. Moore, Solid State Chemistry-An Introduction, 3rd Ed., CRC Press, 2005.
7. A. R. West, Basic Solid State Chemistry, 2nd Ed., John Wiley & Sons, 2000.

SEMESTER - III

Course Name - Physical Chemistry Practical-III

**Course Code - SBS CH 010309 SE 0084**

**Credits: 4**

***Course Objective and Learning Outcomes:***

##### *To provide students exposure of solution chemistry, phase rule, spectrophotometry, polarimetry, ultrasonic interferometry and pH metry, potentiometry and conductometry experiments. Advanced experiments such as ultrasonic interferometer and spectrophotometer will be carried out. First-hand experience of polarimeteric studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*

**UNIT I: CONDUCTOMETRY, pH METRY AND SPECTROPHOTOMETRY**

##### *Conductometry*

* Determination of the equivalent conductance of strong electrolytes such as HCl, KCl, KNO3, AgNO3 and NaCl and the validity of Onsager equation.
* Determination of the solubility of lead sulfate and silver halides.
* Conductometric titration of Strong acid *vs*. strong base, weak acid *vs*. strong base, Strong acid *vs*. weak base, weak acid *vs*. weak base using conductivity meter.
* To find CMC value of a given surfactant solution.

*pH Metry*

* Acid base titration of a non-aqueous media using pH meter.
* Determination of dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
* To determine the strength of strong acid versus weak base (NH4OH), weak acid versus weak base, strong and weak acid mixture against a weak base using a pH meter.
* To determine the thermodynamic parameter for a reaction from pH measurement.
* To prepare a series of buffer solution and to check resist in its pH value by pH meter method.
* To determine the degree of hydrolysis and hydrolysis constant of aniline, acetic acid by pH metrically.

*Colorimetry/Spectrophotometry*

* Determine the concentration of Crystal violet and Aurine in mixture of (Crystal violet + Aurine) solution.
* To determine the dissociation constant (Ka)of Methyl red using UV-visible absorption spectrophotmeter.
* Verification of Beer law using solutions such as I2 in CCl4, and CuSO4 in water, K2Cr2O7 and KMnO4 in sulphuric acid medium.

*Polarimetery*

* To determine the concentration of an optically active substance.
* To determine the percentage of two optically active substances in a given mixture.

*Solution Chemistry*

* Determination of Solubility by evaporation method.
* Determination of Solubility by gravimetric method.
* Determination of transition temperature by thermometric method.

**UNIT II: PHASE RULE AND POTENTIOMETRY EXPERIMENTS**

*Phase Rule*

* To verify the phase rule for a given two and three component Azeotropic mixtures.
* To determine the transition temperature of given salt hydrate like Sodium sulphate, Strontium sulphate or Sodium thiosulphate.
* To determine the critical solution temperature of phenol water system.

*Potentiometry*

* To determine the thermodynamic parameters for a reaction from EMF measurement.
* To determine the formal potential of a redox couple, Fe(CN)63-/Fe(CN)64- in different media.
* To determine the pH of a series of buffer solutions by potentiometric method.
* To determine the solubility product of AgCl and to determine instability constant of Ag(NH3)2+ complex.
* To determine the activity of hydrogen ion in acid medium using hydrogen electrode, hence to determine the ionic product of water and hydrolysis constant of sodium acetate.
* To determine the degree of hydrolysis and hydrolysis constant of aniline, weak acid by potentiometry.
* To determine the concentration of a reductant or an oxidant i.e. Ferrous ammonium sulphate and Ceric sulphate by a potentiometric redox titration.
* To determine the amount of KI and KCl present in a mixture by potentiometric titration.

*Ultrasonic Interferometer*

* To find ultrasonic speed of given organic binary liquid mixtures of different composition.
* To study the effect of temperature on ultrasonic speed of given organic mixture.

*(Note: Depending on availability of time and equipment’s, some experiments may be added/deleted during the semester).*

**Suggested Readings:**

1. Senior Practical Physical Chemistry, B. D. Khosla, V. C. Garg, Adarsh Gulati, R. Chand & Co., New Delhi, 2014.
2. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central book Agency, 2012.
3. Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan, M V Learning, 2010.
4. Experiments in Physical Chemistry, Shoemaker and Gailand, McGraw Hill, 2005.
5. R. C. Das, B. Behara, Experimental Physical Chemistry, , Tata McGraw Hill, 1984.
6. Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House, 1981.
7. M. James, F. E. Prichard, Practical Physical Chemistry, Lomgman, 1974.
8. P. Levitt, Findley’s Practical Physical Chemistry, 9th ed. Longman Group Ltd., 1973.

**SEMESTER-IV**

Course Name - Physical Chemistry-V (Polymer & Surface Chemistry)

**Course Code - SBS CH 010414 SE 4004**

**Credits: 4**



***Course Objective and Learning Outcomes:***

*To provide students with an understanding of advanced physical chemistry like polymer chemistry, polymer characterization and chemistry of surfactants. This course will strengthen the fundamentals of Physical Chemistry, especially polymer chemistry and chemistry of surfactants.*

**UNIT І: POLYMER CHEMISTRY**

Classification of polymers, Polymerization: Condensation, Addition, Radical chain, Ionic, Coordination and Co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems. Kinetics of polymerization. Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution.

**UNIT-II: POLYMER CHARACTERIZATION**

The practical significance of molecular weight. Measurement of molecular weights: End-group, Osmotic and Ultracentrifugation methods. Analysis and testing of polymers: Chemical analysis of polymers, Spectroscopic methods and Microscopy. Thermal analysis and physical testing: Tensile strength, fatigue, impact, tear resistance and hardness and abrasion resistance.

**UNIT–III: CHEMISTRY OF SURFACTANTS-I**

Adsorption of surface active agents at Solid/Liquid, Liquid/Gas and Liquid/Liquid interfaces. Mechanism of adsorption, adsorption isotherm, effects of adsorption from aqueous solution on the surface properties of solid adsorbent, adsorption from non-aqueous solution. Determination of surface areas of solids. Gibb’s and BET adsorption equation and its utilization to calculate surface concentration and surface area per molecule.

**UNIT-IV: CHEMISTRY OF SURFACTANTS-II**

Critical micelle concentration (CMC), Methods of determining CMC, Factors affecting CMC, Micellar structure and shape, Micellar aggregation. CMC in non-aqueous media. Thermodynamic parameters of micellization.

Effectiveness of adsorption at Liquid/Gas and Liquid/Liquid interfaces, Szyszkiwski, Langmuir and Frumkin adsorption equations. Derivation of thermodynamics parameters of adsorption at the Liquid/Gas and Liquid/Liquid interfaces.

**Suggested Readings:**

1. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer Science, New Age Internat. Pvt. Ltd., 2015.
2. F. W. Billmeyer Jr., Textbook of Polymer Science, Wiley India Pvt. Ltd., 2014.
3. M. J. Rosen, Surfactants and Interfacial Phenomenon, 4th ed., Wiley, 2012.
4. P. Becher, Emulsions: Theory and Practice, American Chemical Society, 2011.
5. H. R Alcock and F. W. Lamb, Contemporary Polymer Chemistry, Prentice Hall, 2011.
6. J. M. G. Cowie, Physics and Chemistry of Polymers, Blackie Academic and Professional, 2004.
7. F. Wold, Macromolecules: Structure and Function, Prentice Hall of India, 2001.
8. K. Takemoto, R. M Ottanbrite and M. Kamachi, Functional Monomers and Polymers, 2nd Ed., CRC press, 1997.

**SEMESTER-IV**

Course Name - Physical Chemistry-VI (Applied Electrochemistry)

**Course Code - SBS CH 010415 SE 4004**

**Credits: 4**



***Course Objective and Learning Outcomes:***

*To provide students with an understanding of applied physical chemistry like electrodics, fuel cell and batteries, current potential laws and corrosion of metals and their alloys. This course will strengthen the applications of Physical Chemistry, especially fuel cells and batteries and corrosion.*

**UNIT I: ELECTRODICS**

Rate of charge transfer reactions under zero field, under the influence of an electric field. The equilibrium exchange current density, the non-equilibrium drift-current density (Butler-Volmer) equation. High-field and low-field approximations. Physical meaning of the symmetry factor (β), A simple picture of the symmetry factor and its dependence on over potential. Polarizable and nonpolarizable interfaces.

**UNIT II: FUEL CELLS AND BATTERIES**

The maximum intrinsic efficiency, Actual efficiency and Current-Potential relation in an electrochemical energy converter. Factors influencing the electrochemical energy conversion, The power output of an electrochemical energy converter. Electrochemical electricity generators (fuel cells). Brief idea about H2-O2 fuel cell, Hydrocarbon-air fuel cells, and Natural gas, CO-air fuel cells, Electricity storage: Some important quantities in electricity storage (like electricity storage density, energy density and power), Desirable conditions for an ideal storer, Storage of electricity using the lead-acid battery, Dry cell, Silver-Zinc cell and Sodium-Sulfur cell.

**UNIT III: CORROSION**

Electrochemistry of corrosion of metals, Factors affecting corrosion, Electrochemical cell formation, Polarization of metal electrode *i.e*. Concentration, Resistance and Activation polarization. Anodic and cathodic polarization curves (Evan’s diagram). Electrochemical measurement of corrosion current density, corrosion potential and mixed potential theory and Tafel slope. Anodic passivation and passivation potential. Passivity theory. Methods of protecting metal and their alloys from corrosion (anodic protection, cathodic protection, sacrificial protection, barrier protection, use of chemical inhibitors, environment modifiers).

**UNIT IV: CURRENT POTENTIAL LAWS**

Application of the current-potential laws, Comparison of electrolytic interface to other type of charged interfaces *i.e.* semiconductors *p-n* junctions. The current across biological membranes, Hot and cold emission of electrons from a metal into vacuum.

**Suggested Readings:**

1. M. G. Fontana, Corrosion Engineering, McGraw Hill Ed., 2017.
2. H. K. Moudgil, Textbook of Physical Chemistry, PHI Publication House, New Delhi, 2015.
3. S. Glasstone, An introduction to Electrochemistry, Est West Press Ltd., 2006.
4. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I, Springer, 2000.
5. R. Narain, An Introduction to Metallic Corrosion, Oxford and IBH Pub Co., 1983.

**DISCIPLINE CENTRIC ELECTIVE COURSES**

**(DCEC)**

**SEMESTER-I**

**Course Name - Household and Applied Chemistry**

**Course Code - SBS CH 010101 DCEC 2002**

#### Credits: 2

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***Course Objective and Learning Outcomes:***

*The course is designed to introduce student about the basic use of chemicals in everyday life. We will make the subject interesting and students can develop his skill towards applied sciences.*

**UNIT I: HOUSEHOLD CHEMICALS**

Household chemicals like floor cleaner, toilet cleaner, food additives and preservatives, tooth paste, mouth wash, shaving cream, after shave, perfumes, deordants, etc. Fire Extinguishers and its types, Antibiotics and Antiseptic drugs, Amino acids and Proteins, carbohydrates.

**UNIT II: OIL, FAT, SOAP AND WAX**

Chemical composition, constitution and cleaning action of the soap and detergents. Difference between soaps and detergents. Saturated and unsaturated fats, good and bad cholesterol, Waxes and its types.

**UNIT III: COSMETICS**

Creams, powders, fragrances, lipsticks, eye and facial makeup, hair colors, dental oral sprays and gels, deodorants, hands sanitizer their chemical compositions and applications.

**UNIT IV: PAINTS AND VARNISH**

Definition, classification and types of varnishes. Ingredients in paints and varnishes. Paint choice and surface preparation.

**Suggested Readings:**

1. F. Wold, Macromolecules: Structure and Function, Prentice Hall, 2009.
2. I. L. Finar, Organic Chemistry, Vol-1, 6th ed., Pearson, 2005.
3. V. P. Sharma, Bio-Organic Chemistry, ed. XI, Pragati Prakshan, 2002.

SEMESTER-I

Course Name - Reaction Mechanism: Structure and Reactivity

**Course Code - SBS CH 010102 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

### *To provide the advance knowledge of Physical Organic Chemistry. At the end of this course, students will learn about the structure, synthesis and stability of various reactive intermediates, thermodyanamic and kinetic approach of product formation, various methods determining an organic reactions and stereoelectronic effects in organic Chemistry*

**UNIT I: REACTIVE INTERMEDIATES**

Introduction to structure, formation, stability and reactions of carbocations, carbanions, free radicals, radical anions, radical cations, arynes, carbenes and nitrenes.

**UNIT II: CHEMICAL EQUILIBRIA AND CHEMICAL REACTIVITY**

Thermodynamic and kinetic control of reactions, Correlation of reactivity with structure, linear free energy relationships, substituent constants and reaction constants. Hammond’s postulate; Curtin-Hammett principle.

**UNIT III: KINETICS AND NON-KINETIC METHODS TO STUDY MECHANISM**

Kinetic methods: primary and secondary kinetic isotopic effects; non-kinetic methods: study of intermediates, isotopic labeling, stereochemical studies and cross over experiments.

**UNIT IV: STEREOELECTRONIC EFFECTS IN ORGANIC CHEMISTRY**

Reactions at sp3, sp2, and sp carbons (Baldwin’s rule); Allylic starin (A1,2 and A1,3) and other strains.

#### Suggested Readings:

1. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A, 5th ed., Springer, 2012.
2. E. V. Anslyn and D. A. Dougherty, Modern Physical Organic Chemistry, University Science Books, 2005.
3. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2nd ed., Oxford University Press, 2001.
4. J. March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure, 4th ed., John-wiley, 1999.
5. N. S. Isaacs, Physical Organic Chemistry, 2nd ed., Longman Scientific & Technical, 1995.
6. P. Sykes, A guide book to Mechanism in Organic Chemistry, 5th ed., Longman Scientific Technical, 1985.
7. P. Deslongchamps, Stereoelectronic Effects in Organic Chemistry, Pergamon, 1983.

**SEMESTER-I**

**Course Name - Chemistry of Nutraceuticals**

**Course Code - SBS CH 010103 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

### *To provide the basic knowledge and understanding of nutraceuticals and chemistry involved. At the end of this course, students will learn about the history, source, occurrence, chemistry, metabolism, scope and future perspective of nutraceuticals.*

**UNIT I: INTRODUCTION**

Introduction of nutraceuticals, Historical perspective, classification, Sources of Nutraceuticals, Scope & future prospects.

**UNIT II: CHEMISTRY OF CARBOHYDRATES**

Structure, Function, Classification, Glycogen metabolism, its breakdown, glycogen storage diseases, Glycolysis, gluconeogenesis

**UNIT III: PROTEIN AND ITS DISTRIBUTION**

Essential and nonessential amino acids, classification, denaturation of proteins, Metabolic breakdown and synthesis of amino acids, Distribution of proteins, amount and type of proteins in food groups, vegetable proteins, proteins of egg, fish, milk, soya, Storage proteins of cereals and legumes, anti-freeze proteins, stress proteins.

**UNIT IV: LIPIDS AND NUCLEIC ACIDS**

Classification, saturated and unsaturated, essential fatty acids, structure and function of acylglycerols, phospholipids, sphingolipids, glycolipids, steroids

Nucleic Acids: Structure of nucleotides, DNA, forms of DNA, replication, transcription and translation

#### Suggested Readings:

1. W. R. Victor, A. B. David, M. B. Kathleen, J. K. Peter and P. A. Weil, Harpers Illustrated Biochemistry, 31st ed., Lange, 2015.
2. J. Clayden, B. Greeves and S. Warren, Organic Chemistry, second ed., Oxford University Press, 2012.
3. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 7th ed., W.H. Freeman & Com, 2012.
4. P. Y. Bruce and K. J. R. Prasad, Essential Organic Chemistry, Pearson Education, New Delhi, 2008.

**SEMESTER-II**

Course Name - Green and Sustainable Chemistry

**Course Code - SBS CH 010204 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

### *To provide the knowledge and understanding of principles and concept of Green Chemistry. At the end of this course, students will learn about the sustainable development, catalysis and renewable raw materials and use of alternative solvents towards the development of green technology and alternative energy.*

**UNIT I: PRINCIPLES AND CONCEPTS OF GREEN CHEMISTRY**

Chemistry in the context of sustainable development, Current status and future perspective. The twelve principles of Green Chemistry.

**UNIT II: CATALYSIS AND RENEWABLE RAW MATERIALS**

Introduction to catalysis. Homogeneous and Heterogeneous catalysis, Phase-transfer catalysis and Biocatalysis. Chemical products based on renewable sources.

**UNIT III: ALTERNATIVE SOLVENTS**

Volatile organic compounds (VOCs) Supercritical fluids. Alternatives in extraction and chromatography. Ionic liquids as solvents: its types, properties and applications.

**UNIT IV: GREEN TECHNOLOGY AND SOURCES OF ALTERNATIVE ENERGY**

Photochemical and Electrochemical reactions. Reactions under Microwave, sonication and ball milling. Flow techniques.

#### Suggested Readings:

1. S. E. Manahan, Fundamentals of Environmental Chemistry, 3rd ed., CRC Press, 2009.
2. R. A. Sheldon, I. Arends and U. Hanefeld, Green Chemistry and Catalysis, 1st ed., Wiley-VCH, 2007.
3. V. K. Ahluwalia and M. Kidwai, New Trends in Green Chemistry, 1st ed., Springer, 2004
4. T. Clifford, Fundamentals of Supercritical Fluids, 1st ed., Oxford press, 1999.
5. C.-J. Li, T.-K. Chan, Organic Reactions in Aqueous Media, 1st ed., Wiley-Interscience, New York, 1997.

**SEMESTER-II**

**Course Name - Introduction to Nanomaterials**

**Course Code - SBS CH 010205 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*This course is designed to give exposure of nanomaterials and chemistry of it to the fresh postgraduate students. Many important nanomaterials such as graphene, carbon nanotubes, nanorods etc, their classification, synthesis, characterization and applications would be introduced to the students.*

**UNIT I: INTRODUCTION**

Nanomaterials: An Introduction. Nanomaterials and Nanocomposites. Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials - one dimensional (1D)-two dimensional (2D)-three dimensional (3D) nanomaterials.

**UNIT II: SYNTHESIS**

Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes.Radio- and Microwave Plasma Processes. Flame Aerosol Process. Synthesis of Coated Particles.

**UNIT III: CHARACTERIZATION**

Characterization of Nanomaterials: Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy.

**UNIT IV: NANOTUBES, NANORODS, AND NANOPLATES**

Introduction of Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Carbon Nanotubes and Graphene, Nanotubes and Nanorods from Materials other than Carbon, Synthesis of Nanotubes and Nanorods.

#### Suggested Readings:

1. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley-VCH, 2013.
2. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials, World Scientific, 2013.

**SEMESTER-II**

**Course Name - Analytical Techniques in Chemistry**

**Course Code - SBS CH 010206 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

### *To provide the advance knowledge various analytical techniques in Chemistry. At the end of this course, students will learn various methods of analytical chemistry such as thermal, imaging and chromatographic techniques.*

**UNIT І: THERMAL METHODS**

Principle, instrumentation of TGA, DTA, and DSC. Effect of heat on Materials, Chemical decomposition and T. G. Curves, Analysis of T.G. curve to show nature decomposition reactions, the product and qualities of compounds expelled, T.G. in controlled atmosphere, applications. DTA, instrumentation and Methodology, applications.DSC, theory, instrumentation and applications. Thermometric titrations method and applications.

**UNIT II: IMAGING TECHNIQUES**

An introduction to microscopy, the transmission and scanning electron microscope, electron optics, TEM specimens preparation and imaging system, kinematics of scattering by atomic nucleus, electron electron scattering, dynamics of scattering, electron diffraction pattern, operating principle of SEM, penetration of electron in solids, secondary electron images backscattered electron images, SEM operating conditions and specimen preparation, electron beam lithography.

**UNIT III: CHROMATOGRAPHIC TECHNIQUES**

Theory, instrumentation and applications of: Exclusion chromatography, gel permeation, retention behavior, inorganic molecular sieves, determination of molecular weight of polymers. Super Critical fluid Chromatography, Inverse gas chromatography, Affinity Chromatography

**UNIT IV**: **ANALYSIS OF METAL, ALLOYS, SOIL AND FERTILIZERS**

Foundry materials, analysis of coal, ferroalloys, and special steels, slags, fluxes, brass and bronze. Method of soil analysis, soil fertility its determination, determination of inorganic constituents of plant materials, Chemical analysis as measure of soil fertility, analysis of fertilizers.

#### Suggested Readings:

1. G. D. Christian, Analytical Chemistry, 7th ed., Wiley, 2014.
2. R. F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AFM, 2013
3. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, Instrumental methods of analysis, 7th ed., 2010.
4. T. Braun and G. Ghersene, Extraction chromatography, Elsevier, 2002
5. D. A. Skoog, D. M. West, R. J. Holler and T. A. Nieman. Principles of Instrumental Analysis, 5th ed., Neiman, 2001
6. S. M. Khopkar, Concepts in analytical Chemistry, 1995

**SEMESTER-II**

**Course Name - Computational Chemistry**

**Couse Code - SBS CH 010207 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

### *To provide the basic knowledge of computational Chemistry. At the end of this course, students will learn various parameters and software involved in computational Chemistry and its application towards understanding the stability of molecules and proposing its reaction mechanism.*

**UNIT I: INTRODUCTION TO COMPUTATIONAL CHEMISTRY**

Computational chemistry map, scope of computational chemistry, Born-Oppenheimer approximation, idea of self-consistency, restricted and unrestricted Hartree-Fock.

**UNIT II: DENSITY FUNCTIONAL THEORY**

Electron density, exchange-correlation functional, local Density approximation, generalized gradient approximation, hybrid density functional methods, self-Interaction corrections.

**UNIT III: BASIS SETS AND POTENTIAL ENERGY SURFACES**

Definition of basis sets, Slater and Gaussian type orbitals, minimal, double-zeta, split-valence, core-valence, Pople style basis Sets, polarization and diffuse functions, calculation of basis functions, pseudopotentials or effective core potentials, choice of basis bets.

**UNIT IV: BASIC CONCEPTS OF POTENTIAL ENERGY SURFACES**

Stationary Points, geometry optimization, local and global minima, and transition state theory.

Computations of single point energy, optimizations and transition states of polyatomic molecules, intrinsic reaction coordinate analysis.

#### Suggested Readings:

1. J. B. Foresman and A. Frisch, Exploring Chemistry with Electronic Structure Methods, 2nd ed., Gaussian Inc., 2015.
2. F. Jensen, Introduction to Computational Chemistry, John Wiley & Sons, 2007
3. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd ed., John Wiley & Sons Ltd, 2004.
4. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd ed., John Wiley & Sons Ltd, 2002.
5. D. A. McQuarrie, Physical Chemistry: A molecular Approach, 1st ed., University Science Books, 1997.

**SEMESTER-II**

**Course Name - Carbohydrate Chemistry and its Applications**

**Course Code - SBS CH 010208 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To understand the chemistry of carbohydrates and their reactions in addition to their importance.*

*At the end of this course, students will acquire the knowledge of different classes of carbohydrates. They will also learn about the chemical, physical and stereochemical aspects of carbohydrates in addition to their applications.*

**UNIT I: CARBOHYDRATES-I**

Introduction and biomedical Importance, Classification: Monosaccharides, oligosachharides and polysaccharides, Sugars and non-sugars, Reducing and non-reducing sugars.

Monosaccharides: Nomenclature, Structural representation, Isomerism. Physical and chemical properties of some important monosaccharides including stereochemical aspects wherever needed.

**UNIT II: CARBOHYDRATES-II**

Synthesis of glucose and fructose.

Oligosaccharides: Nomenclature and important terminology, Structural representation, Isomerism, physical and chemical properties of some important disaccharides (lactose, maltose and sucrose).

**UNIT III: CARBOHYDRATES-III**

Polysaccharides: Nomenclature and important terminology, Homo and heteroploysaccharides, Structural representation. Physical and chemical properties of some important polysaccharides (Cellulose, Starch, Chitin). Glycolysis: Metabolism of Glucose.

**UNIT IV: CARBOHYDRATE-IV**

Applications: Importance of monosaccharides and their derivatives like deoxy sugars, glycosides, myoinositol, amino sugars, *N*-acetylmuramic acid, sialic acid in different fields. Importance of oligosaccharides and polysaccharides in different sectors. Artificial sweeteners: Synthesis and importance

#### Suggested Readings:

1. P. Y. Bruice, Organic Chemistry, 5th Edition, Pearson, 2014.
2. M. Sinnott, Carbohydrate Chemistry and Biochemistry: Structure and Mechanism, 2nd Edition, Royal Society of Chemistry, 2013.
3. P. Y. Bruce and K. J. R. Prasad, Essential Organic Chemistry, Pearson Education, New Delhi, 2008.
4. T. K. Lindhorst, Essentials of Carbohydrate Chemistry and Biochemistry, 3rd Edition, Wiley, 2007.
5. L. Nelson, M. M. Cox and W. H. Freeman, Lehninger Principles of Biochemistry, 4th edition, 2004.
6. M. Loudon, Organic Chemistry, Oxford University Press, New Delhi, 2002.

**SEMESTER-II**

**Course Name - Nanoparticulate Drug-Delivery Systems**

**Course Code - SBS CH 010209 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To provide students exposure about various drug molecules and how they are delivered using improvised delivery vehicles made of various nanomaterials.*

**UNIT I: NANOPARTICULATE DRUG-DELIVERY SYSTEMS**

Introduction, methods of measurements and characterization of nanomaterials, manufacture of nanomaterials, drug-delivery systems, some commercially available nanoparticles.

**UNIT II: DRUG NANOCRYSTALS**

The universal formulation approach for poorly soluble drugs-Definition, physicochemical properties of drug nanocrystals, potential clinical advantages of drug nanocrystals, particle size reduction techniques, final formulations for drug nanocrystals.

**UNIT III: BIOLOGICAL REQUIREMENTS FOR NANOTHERAPEUTIC APPLICATIONS**

The chemical compositions of cells, fabrication of nanodevices, nanotherapeutic devices, requirements for nanotherapeutic applications.

**UNIT IV: PHARMACEUTICAL APPLICATIONS**

Advantages of nanoparticulate drug-delivery systems, nanoparticulate drug-delivery systems for proteins and peptides, nanoparticulate drug-delivery systems for central nervous system, nanoparticulate drug-delivery systems for enzymes, nanoparticulate drug delivery in cancer treatment, nanoparticulate systems: known and unknown risks.

#### Suggested Readings:

1. Y. Yeo; Nanoparticulate Drug Delivery Systems: Strategies, Technologies, and Applications, John Wiley & Sons, Inc., Hoboken, New Jersey, 2013.
2. Y. Pathak and D. Thassu; Drugs and Pharmaceuticals Sciences: Drug Delivery Nanoparticles Formulation and Characterization, Volume 191, Informa Healthcare, New York, 2009.
3. D. Thassu, M. Deleers and Y. Pathak; Drugs and Pharmaceuticals Sciences: Nanoparticulate Drug-Delivery Systems, Volume 166, Informa Healthcare, New York, 2007.

**SEMESTER-III**

Course Name - Waste Management

**Course Code - SBS CH 010310 DCEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*The course is designed to understand the nature of human induced environmental pollutions like waste, its significance, sources, compositions and types. Initiate waste to energy initiatives for integrated/sustainable waste management options.*

**UNIT I: BIODEGRADABLE SOLID WASTE**

Biodegradable solid waste: Chemical composition and classification: Source and generation: Health hazards: Management Techniques

**UNIT II: NON-BIODEGRADABLE SOLID WASTE**

Non-Biodegradable Solid waste: Sources, generation, chemical composition, classification of plastic waste and its management: Sources, generation, chemical composition, classification of e-waste and its management.

**UNIT III: HOSPITAL AND PHARMACEUTICAL WASTE**

Hospital and Pharmaceutical Waste: Classification: Source and generation: Health hazards: Management Techniques

**UNIT IV: WASTE MINIMIZATION TECHNOLOGIES**

Waste minimization technologies: Reuse/ recycling of different types of waste: Metal recovery from waste using chemical, biological and hybrid techniques

#### Suggested Readings:

1. D. Pant, D. Joshi, M. K. Upreti and R. K. Kotnala, Chemical and Biological Extraction of Metals Present in E Waste: A Hybrid Technology, Waste Management, Elsevier Science, Vol. 32, pg. 979-990, 2012.
2. D. Pant, R. Singh, S. Kumar, Management of Waste Poly Vinyl Chloride (PVC) through Chemical Modification, ScInd Res., Vol. 71, pg. 181-186, 2012.
3. D. Pant, Waste Management in Small Hospitals Trouble for Environment, Environmental Monitoring and Assessment, Springer, 2011.
4. D. Pant, Pharmaceutical Waste Management, Lambart Academic, 2011.
5. D. Pant, Electronic Waste Management Lambart Academic Publishing, 2010.
6. Frank Kreith, Handbook of Solid Waste Management, McGraw-Hill, Inc., New Delhi, 1994.
7. M. Roy III. Harrison, Pollution; Causes, Effects and Control. The Royal Society of Chemistry, Cambridge, 1994.
8. John R. Holmes, Practical Waste Management, John Wiley & Sons, New York/Singapore, 1983.

SEMESTER-III

Corse Name - Chemistry of Toxic Substances

Course Code - SBS CH 010311 DCEC 4004

**Credits: 4**

***Course Objective and Learning Outcomes:***

*The course is designed to introduce students to the fundamental concepts of toxic and hazardous waste; provide knowledge about the identification of various toxic and hazardous waste, and introduce Management techniques for toxic and hazardous waste.*

**UNIT I: PHYSICAL AND TOXIC PROPERTIES OF CHEMICAL SUBSTANCES INCLUDING HAZARDOUS WASTE**

Pathway of entry, Detoxication, Bioactivation, Vapor pressure, Vapor density, Solubility

**UNIT II: TOXIC AND HAZARDOUS CHARACTERISTIC VARIOUS ORGANIC CHEMICALS**

Acids, Aldehydes, Amines, Dioxins, Ethers, Cyanides.

**UNIT III: COMMON TOXIC AND FLAMMABLE GASES AND CANCER-CAUSING CHEMICALS**

Hydrogen, Carbon mono and dioxide, Nitrogen Oxide, Concept of carcinogenesis, Mechanism of chemical carcinogens, Human carcinogens

**UNIT IV: HAZARDOUS PROPERTIES OF SOME CHEMICALS AND MANAGEMENT TECHNIQUES**

Arsenic, Cadmium, Lead, Mercury, Insecticides, Asbestos, Flyash, Ozone and PAN pesticides, Chemical and Biological agents including warfare Agents, Management techniques for toxic and hazardous waste.

**Suggested Readings:**

1. P. Patnaik, A Comprehensive Guide to the Hazardous Properties of Chemical Substances (3rd ed.) John Wiley & Sons, Inc., Hoboken, New Jersey, 2015.
2. Healtth Hazards of Environmental Arsenic Poisoning, Imperial College Press. (ISBN 978-981-4291-81-1), 2015.
3. H. K., Moffatt and Shuckburgh, Environmental Hazards, Imperial College Press, 2012.
4. C. Oloman, Material and Energy Balance for Engineers and Environmentalist, Imperial College Press, 2009.
5. T. F. Yen, Chemical Processes for Environmental Engineering, Imperial College Press, 2007.
6. C. N. Madu, Environmental Planning and management, Imperial College Press, 2004.
7. L. C. Batty and K. B. Hallberg, Ecology of Industrial Pollution, Cambridge University press, New Delhi, 2002.

**SEMESTER-III**

Course Name - Environmental Chemistry

**Course Code - SBS CH 010312 DCEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*The course is designed to  introduce students to the fundamental concepts of analytical techniques environmental chemistry;  provide knowledge about various kinds of quantitative techniques; and introduce computation of analytical results, significant figures, concept of error, precision and accuracy, standard deviation, rejection of doubtful values.*

**UNIT I: FUNDAMENTAL CONCEPTS**

Parameters for monitoring**,** Environmental Divisions**,** Natural Cycles

**UNIT II: CHEMISTRY OF AIR**

* Introduction
* Air Pollutants and its source
* Toxic effects of Carbon monoxide, Nitrogen Oxide, Sulphur Oxides.
* Acid rain
* Depletion of Ozone Layer
* Particulate matter (PM)
* Smog

**UNIT III: CHEMISTRY OF WATER**

* Water Pollution
* Oxygen demanding waste
* Disease Causing waste
* Synthetic organic compounds and oil pollutant
* Inorganic Pollutant
* sediments
* Radioactive Materials
* Thermal Pollution

**UNIT IV: WATER AND SOIL POLLUTION**

* Domestic water quality
* Industrial water quality
* Trace /Heavy elements in water and their removal
* Waste water treatment
* Types of rocks
* Cause of soil pollution
* Control of soil pollution

**Suggested Readings:**

1. Gary W. Vanloon, Environmental Chemistry, New York: Oxford, 2010.
2. S. Manahan, Environmental chemistry, Boca Raton: CRC, 2010.
3. M. N. Rao, Air pollution, New Delhi: TMH, 2010.
4. O'Neill, Environmental chemistry, London: Blackie, 2009.
5. M. Srivastava, Environmental Chemistry, Delhi: Sree, 2009.
6. G. Vanloon, Environmental Chemistry, New York: Oxford, 2009.
7. Levin, Aerosol pollution impact on precipitation. New York Springer, 2009.
8. J. Rogers, Environment and water resources, USA: ASCE, 2007.
9. Ronand Marcos, Biological waste water treatment in warm climate regions, London: IWA, 2006.
10. J. S Bali, Bioindustrial Watershed Management. New Delhi: JCS, 2005.
11. S. E. Manahan, "Frontmatter "*Environmental Chemistry* Boca Raton: CRC Press LLC, 2000.
12. K. Bucher, Global Climate, Wiley, New York 1976.
13. J. Heichlen, Atmospheric Chemistry, Academic Press, New York 1976.
14. A. K. De, Environmental Chemistry 4th ed., New Age International (P) Ltd., New Delhi.

**SEMESTER-III**

**Course Name – Agrochemicals**

**Course Code - SBS CH 010313 DCEC 2002**

**Credits: 2**

### *Course Objective and Learning Outcomes:*

### *To provide the knowledge of pesticides, fertilizes, soil science and plant growth regulators. At the end of this course, students will learn history, importance, occurrence, chemistry and futures perspective of agrochemicals.*

### UNIT I: PESTICIDES

Pests and Pesticides, History of pesticide use, Chemical and Botanical pesticides, Classification based on chemical nature, and types of targets, Systemic and nonsystemic pesticides. Insecticides, Herbicides, Fumigants and Rodenticides. Various chemical classes of pesticides. Environmental and health hazards f pesticides, Semiochemicals.

**UNIT II: FERTILIZERS**

Classification and types of fertilizers, Essential fertility requirement of the Nitrogenous fertilizers: Ammonium nitrate, Urea, Calcium Cyanamide, Calcium Ammonium Nitrate, Phosphate fertilizers: Normal super phosphate, Triple Super Phosphate, Ammonium Phosphate; Potassic fertilizers, Indian Fertilizer Industry. Biofertilizers

**UNIT III: SOIL SCIENCE AND MICRONUTRIENTS**

Importance of Soil formation, Properties and Composition of Soils, Soil profile, Organic matter in soil, Soil micronutrients, Acid and Alkaline soil, Absorption of toxic metal and chemicals by soil, Nitrogen fixation and its chemistry, Micro- nutrients, Manufacture of Micronutrients.

**UNIT IV: PLANT GROWTH PROMOTERS AND HORMONES**

Various plant growth promoters and hormones, chemical structures and types; Gibberellins, Auxins, Cytokinins, Abscicic acid, Ethylene. Synthetic plant hormones.

#### Suggested Readings:

1. B. K. Sharma, Industrial Chemistry, 2013.
2. F. E. Bear, Chemistry of the soil, 2nd ed., Scientic Publsihers, 2012.
3. A. M. Deshmukh, R. M. Khobragade and P. P. Dixit, Handbook of Biofertilizers and Biopesticides, ABD Publishers, 2007.
4. M. Ashman and G. Puri, Essential Soil Science: A Clear and Concise Introduction to Soil Science, Wiley-Blackwell, 2002.
5. M. B. Green, G. S. Hartley and T. F. West, Chemicals for Crop Improvement and Pest Management, Pergamon Press, 1987.
6. N. N. Melnikov, Chemistry of Pesticides, Springer, 1971.

**SEMESTER-III**

Course Name - Industrial Chemistry

Course Code - SBS CH 010314 DCEC 2002

**Credits: 2**

***Course Objective and Learning Outcomes:***

### *To provide the basic knowledge of Chemicals and process involved in Chemical Industry. At the end of this course, students will learn about the Inorganic Chemicals, blends and additives, petrochemicals and various kind of pollutions produced by industry and its remedies.*

**UNIT I: INTRODUCTION TO INORGANIC CHEMICALS**

Sulphuric acid, phosphoric acid, lime, soda ash, titanium dioxide, sodium chloride and chloralkali. Industrially important polymers: polyethylene, polypropylene, polyvinyl chloride, polyester, nylon, fluoropolymers, acetal resins.

**UNIT II: BLENDS AND ADDITIVES**

Blends, antioxidants, UV stabilizers, antistatic agents, peroxides, lubricants, fire retardants, heat stabilizers, plasticizers. Agricultural Chemicals: Fertilizers, insecticides, herbicides, fungicides.

**UNIT III: PETROCHEMICALS**

Crude oil and natural gas, refinery operations, energy consumption, lower olefins and acetylenes, cracking processes, synthesis gas, ammonia and methanol production, acetic acid and acetic anhydride production, C1 products : Formic acid, hydrogen cyanide, chloromethanes, C2 products: ethanol, acetaldehyde, ethylene oxide.

**UNIT IV: INDUSTRIAL POLLUTION**

Source of Pollution: Air pollution-various pollutants, Water pollution-Organic/inorganic pollutants, Noise pollution, Pesticide pollution, Radiation pollution. Control and treatment of pollution and waste from industrial sites.

**Suggested Readings:**

1. A. Heaton, An introduction to Industrial Chemistry, 3rd ed. Springer Science, 2013.
2. Kanwar and Chopra, Analytical agricultural Chemistry, 2008.
3. J. A. Tyrell, Fundamental of Industrial Chemistry, Wiley, 2005.
4. T. Godish, Air quality, 5thed, CRC Press, 2002.

**SEMESTER-III**

Course Name - Carbon Management

**Course Code - SBS CH 010315 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*Course will provide scientific understanding of Carbon Management or sequestration and develop to the point of deployment those options that ensure environmentally acceptable sequestration to reduce anthropogenic CO2 emissions and/or atmospheric concentrations.*

**UNIT I: INTRODUCTION OF CARBON MANAGEMENT**

Background concepts, Change in carbon pools, management plans are focused on (*a*) minimizing emission (*b*) maximizing environmentally sound reuse, reduce and recycling; (*c*) effective treatment and (*d*) converting carbon into valuable products with atom economy.

**UNIT II: CHEMICAL AND BIOLOGICAL METHODS FOR CARBON MANAGEMENT**

Various chemical reaction involved in carbon management like as Kolbe-Schmitt, Carboxylation, cyclization, polymerization, amination, Boudouard reaction, Friedel-Crafts acylation, Reductive hydrogenation, photochemical and Formato-metal complex reactions, Carbon capture from adsorbents, Membrane based separation. Biological sequestration relates to the use of higher plants and micro-organisms**, Microbial electrosynthesis,** Symbiosis (in *vivo* associations of plant and microbes).Chemical-biological Hybrid modification

**UNIT III: CARBON CAPTURE AND UTILIZATION**

Carbon capture and Utilization; biotechnological interventions for carbon dioxide capture and utilization, options for mitigating methane emissions, carbon sequestration and organic farming

**UNIT IV: MODIFICATION IN CARBONIC ANHYDRASE (CA)**

Modification in CA in terms residue and group as target. Residue specific modification involving ligand-ligand interaction in terms of substitution/addition and group specific modification targets the various functional groups. Role of metal interaction and solvents/medium.

**Suggested Readings:**

# R. Emmanuel and K. Baker, Carbon Management in the Built Environment, 1st ed., 2013.

# S. Schaltegger, D. Zvezdov, E. I. Alvarez, M. Csutora and E. Günther, Corporate Carbon and Climate Accounting, 2015 (ISBN 978-3-319-27718-9), 2008.

SEMESTER-III

Course Name - Pharmaceutical Chemistry

**Course Code - SBS CH 010316 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*This course will provide a basic understanding of Pharmaceutical Chemistry. At the end of this course, students will learn about the various stages involved in drug design, lead concept and its modification, drug receptors, mode of action and recent developments of anticancer, antibiotics, cardiovascular and psychoactive drugs.*

##### **UNIT I: DRUG DESIGN**

Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism. Theories of drug activity, Quantitative structure activity relationship, Concepts of drugs receptor, Elementary treatment of drug receptor interactions, Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric factors.

##### **UNIT II: ANTINEOPLASTIC AGENTS**

Introduction, cancer chemotherapy, targets of cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Synthesis of any three representative anticancer drugs, Recent development in cancer chemotherapy.

**UNIT III: ANTIBIOTICS AND CARDIOVASCULAR DRUGS**

Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, ciprofloxacin. Introductory idea of tetracycline and streptomycin. Antibiotic resistance, MDR and XDR bacteria and associated challenges.

**UNT IV: LOCAL ANTIINFECTIVE DRUGS AND PSYCHOACTIVE DRUGS**

Introduction and general mode of action of local antiinfectives, Furazolidone, naldixic acid, dapsone, isoniazid, ethambutol, gluconazole, chloroquin and primaquin, Introduction to neurotransmitters, CNS depressants, general anaesthgetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, benzodiazepines, Antipsychotic drugs – the neuroleptics, antidepressants.

#### Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd ed., Academic Press, 2014.
2. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2nd ed., Pearson, 2012.
3. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th ed., Oxford University Press, 2013.
4. Ed. Robert and F. Dorge, Wilson and Gisvold’s Text Book of Organic Medicinal and Pharmaceutical Chemistry, 12th ed., 2010.
5. Ed. M. E. Wolff, Burger’s Medicinal Chemistry and Drug Discovery, Vol. 1, 7th ed., John Wiley, 2010.
6. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st ed., New Age International, 1999.

**SEMESTER-III**

Course Name - Enzymes: Chemistry and Applications

**Course Code - SBS CH 010317 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

##### *To acquire a basic understanding of enzymes and their applications in different sectors. At the end of this course, students will gain the knowledge of enzymes and their advantages in different sectors including organic synthesis.*

##### **UNIT I: ENZYMES-I**

Introduction, Building blocks of enzymes, Chemical and biological catalysis, Properties of enzymes like catalytic power, Specificity and regulation. Enzymes’ classification and nomenclature. Fischer’s lock and key, Koshland’s induced fit hypothesis, Concept and identification of active sites, Enzyme inhibition, Kinetics of enzymatic catalysis.

##### **UNIT II: ENZYMES-II**

Transition-state theory, Orientation and steric effect, Acid-base catalysis, Covalent catalysis. Enzyme mechanisms for chymotrypsin and carboxypeptidase A. Cofactors as derived from vitamins, Coenzymes, Prosthetic group, Apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD+, NADP+, lipoic acid, vitamin B12. Mechanisms of processes catalysed by these cofactors.

##### **UNIT III: ENZYMES-III**

Reactions catalysed by enzymes: Nucleophilic displacement, Group transfer, Addition and elimination reactions, Isomerization, Condensation, β-cleavage, Rearrangements, Carboxylation and decarboxylation reactions.

##### **UNIT IV: ENZYMES-IV**

Applications in different sectors: Food and drink manufacturing, Animal nutrition, Cosmetics, Medication, Pulp and paper industry, Organic synthesis, and Remediation of agro-industrial wastes.

#### Suggested Readings:

1. P. Y. Bruce and K. J. R. Prasad, Essential Organic Chemistry, Pearson Education, New Delhi, 2008.
2. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 4th Edition, W. H. Freeman, 2004.
3. G. Patrick, Medicinal Chemistry, Viva Books Private Limited, New Delhi, 2002.
4. C. M. Loudon, Organic Chemistry, Oxford University Press, New Delhi, 2002.
5. R. B. Silverman, The Organic Chemistry of Enzyme-Catalyzed Reactions, Academic Press, 2000.
6. T. Bugg, An Introduction to Enzymes and Coenzyme Chemistry, Blackwell Science, 1997.
7. H. Dugas, Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Springer Verlag, 1996.

**SEMESTER-IV**

Course Name - Adsorption Science and Technology

**Course Code - SBS CH 010418 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To provide students exposure about adsorption of various small molecules (both gas and vapor) by porous materials and its application in industry and energy storage.*

**UNIT I: GENERAL**

Adsorption kinetics: theory, applications and recent progress, Pressure swing adsorption technology for hydrogen purification, New nanoporous adsorbents (Coordination Polymers, Covalent Organic Frameworks).

**UNIT II: EXPERIMENTAL METHODS**

Experimental methods for single and multi-component gas adsorption equilibria, Experimental determination of heat effects that accompany sorption equilibrium processes, Supercritical adsorption mechanism and its impact to application studies.

**UNIT III: FUNDAMENTALS**

New methodology in the use of super-critical adsorption data to determine the micropore size distribution, Effect of porosity and functionality of activated carbon in adsorption, Phase behavior of simple fluids confined in coordination nanospace.

**UNIT IV: APPLICATIONS**

Storage and separation of small gas molecules (H2, N2, CH4, CO, CO2, C2H2), Large scale CO separation by VPSA using CuCl/zeolite adsorbent.

#### Suggested Readings:

1. L. Zhou, Adsorption, Progress in Fundamental and Application Research, World Scientific, 2007.
2. E. I. Altman, M. Bienfait, H. P. Bonzel, R. Diehl, M. Y. L. Jung, V. G. Lifshitz, M. E. Michel, R. Miranda, R. McGrath, K. Oura, A. A. Saranin, E. G. Seebauer, P. Zeppenfeld, A. V. Zotov, Adsorption on Surfaces and Surface Diffusion of Adsorbates, Springer, 2001.
3. Alírio E. Rodrigues, M. Douglas LeVan, Daniel Tondeur, Adsorption: Science and Technology, Kluwer Academic Publishers, 1989.

**SEMESTER-IV**

Course Name - Asymmetric Catalysis: Fundamentals to Frontiers

**Course Code - SBS CH 010419 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To provide the advance knowledge of asymmetric catalysis in organic synthesis. At the end of this course, students will learn about the basic of asymmetric catalysis, mechanistic studies and its applications in organic synthesis.*

**UNIT I: ASYMMETRIC CATALYSIS**

Basics of asymmetric catalysis including energetic of reactions; Lewis acid and Lewis base catalysis; Chiral auxiliary: Basic requirements of chiral auxiliary; Chiral pool sources:selected examples of few most common chiral auxiliaries (Oppolzer, Evans oxazolidones, Myers amides, 8-phenylmenthol).

**UNIT II: KINETIC RESOLUTION AND DESYMMETRIZATION**

Kinetic, dynamic kinetic and parallel kinetic resolution; Desymmetrization reactions.

**UNIT III: MECHANISTIC STUDIES AND MULTIFUNCTIONAL CATALYSIS**

Mechanistic studies of asymmetric reactions; Non-liner effects and Chiral amplifications. Bifunctional, dual and multifunctional catalyst

**UNIT IV: MODERN ASPECTS OF ASYMMETRIC CATALYSIS**

Modern aspects of asymmetric catalysis: Counteranion directed catalysis, cooperative catalysis, dual and merged catalysis, asymmetric photocatalysis.

#### Suggested Readings:

1. E. M. Carreira, L. Kvaerno, Classics in Stereoselective Synthesis, Wiley-VCH: Weinheim, Germany, 2009.
2. M. Nogrady, Stereoselective Synthesis: A Practical Approach, Wiley, 2008.
3. P. J. Walsh, M. C. Kozlowski, Fundamentals of Asymmetric Catalysis, University Science Book, 2009.
4. A. Berkessel, H. Groger, Asymmetric Organocatalysis: From Biomimetic Concepts to Applications in Asymmetric Synthesis, Wiley-VCH, 2005.
5. I. Ojima, Catalysis in Asymmetric Synthesis, Wiley-VCH, 2004.
6. Recent review and research articles relevant to above topics (reprints to be handed over to students).

**SEMESTER-IV**

Course Name - Toxicology Lab

**Course Code - SBS CH 010420 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*The course is designed to introduce practical exposure about the identification of toxic waste; with management techniques for toxic waste.*

**UNIT I: PRACTICAL EXPOSURE**

* About the identification of toxic waste;
* Management techniques for toxic waste

**UNIT II: PHYSICAL PROPERTIES OF TOXIC**

* Experiment based on physical properties of toxic waste on the basis of vapour pressure, vapour density and solubility

**UNIT III: IDENTIFICATION OF TOXIC SUBSTANCES IN FOOD SAMPLE. IT INCLUDES THE IDENTIFICATION OF**

* Acids,
* Aldehydes
* Amines
* Dioxins
* Ethers
* Cyanides

**UNIT IV: TOXICITY ISSUE RELATED WITH**

* Arsenic
* Cadmium
* Lead
* Mercury
* Carbon monoxide

#### Suggested Readings:

1. C. N. Madu, Environmental Planning and management, Imperial College Press, 2015.
2. Healtth Hazards of Environmental Arsenic Poisoning, Imperial College Press, 2014.
3. T. F. Yen, Chemical Processes for Environmental Engineering, Imperial College Press, 2013.
4. H. K. Moffatt and Shuckburgh, Environmental Hazards, Imperial College Press, 2011.
5. P. Patnaik, A Comprehensive Guide to the Hazardous Properties of Chemical Substances (3rd ed.) John Wiley & Sons, Inc., Hoboken, New Jersey, 2007.
6. C. Oloman, Material and Energy Balance for Engineers and Environmentalist, Imperial College Press, 2005.
7. L. C. Batty and K. B. Hallberg, Ecology of Industrial Pollution, Cambridge University press, New Delhi, 2004.

**SEMESTER-IV**

Course Name - Molecules of Life

**Course Code - SBS CH 010421 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To provide the knowledge fundamentals of molecules of life. At the end of this course, students will learn about the chemistry of molecules of life.*

**UNIT I: NUCLEIC ACIDS**

Secondary structure of DNA and RNA, stabilizing forces, polymorphic nature of DNA, multistranded DNA structures, sequence determination by chemical and enzymatic methods, chemical synthesis of DNA

**UNIT II: PEPTIDES AND PROTEINS**

Classification of naturally occurring peptides, depsipeptides and polypeptide alkaloids, Sequence determination, chemical, enzymatic and mass spectral methods, Modern methods of peptide synthesis with protection and deprotection. Solid phase synthesis, combinatorial synthesis of peptides, Chemistry of oxytocin, valinomycin, enkephalins, self-assembly and aggregation of peptides.

**UNIT III: LIPIDS**

Classification and biological importance of fatty acids and lipids, stereochemical notation in lipids, chemical synthesis of phospholipids and glycolipids, properties of lipid aggregates, micelles, bilayers, lyposomes, and biological membranes.

**UNIT IV: CARBOHYDRATES**

Types of naturally occurring sugars, deoxysugars, amino sugars, branched chain sugars, sugar methyl esters and acid derivatives of sugars, polysaccharides of industrial and biological importance.

#### Suggested Readings:

1. R. P. Sinden, DNA Structure and Function Academic Press, 1994
2. I. L. Finar and A. L. Finar, Organic Chemistry, Vol. 2, Addison Wesley, 1998.
3. I. L. Finar, Organic Chemistry Vol. 1, Longman, 1998.
4. H. Dugas, and C. Penney, Bioorganic Chemistry-A Chemical Approach to Enzyme Action, Springer-Verlag, 1989.
5. M. Bodansky, Peptide Chemistry: A Practical Textbook Springer-Verlag, 1988.
6. W. Saenger, Principles of Nucleic Acid Structure Springer-Verlag, 1984.
7. Ed. M. J. Gait, Oligonucleotide Synthesis-A Practical Approach ORL Press, 1984.

**SEMESTER-IV**

Course Name - Molecular Magnetism

**Course Code - SBS CH 010422 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To provide the basic knowledge of molecular magnetism. At the end of this course, students will learn about the basic concept of magnetism, magnetic interaction, spin transition and magnetic exchange.*

**UNIT I: BASIC CONCEPTS OF MAGNETISATION**

Origin of magnetism, magnetic susceptibility, measurement of magnetic susceptibility: Gouy method, induction method, superconducting quantum interference device magnetometer, Evans method, zero-field cooled measurements, field scan, reduced magnetization, hysteresis, AC susceptibility, classification of magnetic behaviour: diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, antiferromagnetic compounds.

**UNIT II: MAGNETIC INTERACTION**

Classical *vs*. quantum model, Curie Law, Curie-Weiss Law, spin-orbit coupling, anomalous magnetic moments: equilibrium between two spin states, magnetically non-equivalent sites in the unit cell, solute-solvent interaction, solute-solute interaction configurational equilibrium..

**UNIT III: SPIN TRANSITION**

Van Vleck equation, magnetic anisotropy, low spin high spin transition, mechanism of spin transition, spin cooperativity, molecular electronics, intermediate spin and spin-admixed states.

**UNIT IV: MAGNETIC EXCHANGE**

Magnetic exchange, Bleany-Bowers equation, mechanism of exchange coupling, spin hamiltonian, magnetic interaction in oligonuclear complexes, magneto-structural correlations, quantum tunneling of magnetization, single molecule magnets.

#### Suggested Readings:

1. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd ed. Pearson, 2018.
2. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, Oxford University Press, Oxford, 2006.
3. O. Kahn, Molecular Magnetism, VCH Publishers, Inc., Orsay, France, 1993.

**SEMESTER-IV**

Course Name - Analytical Chemistry

**Course Code - SBS CH 010423 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*The course is designed to introduce students to the fundamental concepts of analytical techniques environmental monitoring;  provide knowledge about various kinds of quantitative techniques and introduce computation of analytical results, significant figures, concept of error, precision and accuracy, standard deviation, rejection of doubtful values.*

**UNIT I: ERRORS AND SAMPLE ANALYSIS**

Computation of analytical results, significant figures, concept of error, precision and accuracy, standard deviation, rejection of doubtful values with special reference to volumetric and gravimetric analysis, calibration of analytical equipments. Methods of expressing concentrations, primary and secondary standards.Theory and indicators for neutralizations, oxidation- reduction, precipitation titration.

**UNIT II: GRAVIMETRIC ANALYSIS**

Method of gravimetric analysis, physical gravimetry, thermogravimetry and combustion analysis, precipitative gravimetric analysis, electrodeposition.

**UNIT III: COMPLEXOMETRIC TITRATIONS**

Complexometric methods using EDTA, principle of complexometric titrations, chelating agents, indicators, titrations with disodium edetate.

**UNIT IV: NONAQUEOUS TITRATIONS**

General discussion and principle of titrations in non-aqueous media, aprotic, protophil protogenic and amphiprotic solvents. Titrations with perchloric acid, potassium methoxide and tetrabutyl ammonium hydroxide.

#### Suggested Readings:

1. D. Harvey, Modern Analytical Chemistry, McGraw-Hill Higher Education, New Delhi, 2014.
2. Advances in Sampling and Analysis, John Wiley & Sons, Ltd., 2011.
3. M. L. Shrivastava, Bioanalytical Techniques, New Delhi: Narosa, 2008.
4. G. D. Christian, Analytical chemistry, New Delhi: Wiley, 2004.
5. P. Quevauviller and K. C. Thompson, Analytical Methods for Drinking Water, 2002.
6. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, Vogel’s Text Book of Quantitative Chemical Analysis 5th ed., ELBS, U.K. 1989.
7. Keneth and Connors, A Text Book of Analysis, 3rd ed. Wiley Interscience Singapore, 1982.
8. e-book: D. Pant, Lab Manual Quantitative Analytical Method Book Rix Publication. [www.bookrix.com](http://www.bookrix.com)

**SEMESTER-IV**

Course Name - Antibiotics and Anti-inflammatory Agents: Chemistry and Applications

**Course Code - SBS CH 010424 DCEC 2002**

**Credits: 2**

***Course Objective and Learning Outcomes:***

*To acquire a basic understanding about antibiotics and anti-inflammatory agents. To gain knowledge about their common synthetic routes, mode of action and applications.*

*At the end of this course, students will acquire basic understanding about antibiotics and anti-inflammatory compounds. They would also learn about their common synthetic routes, mode of action and applications.*

**UNIT I: ANTIBIOTICS-1**

Introduction, biomedical importance and classification of antibiotics, common targeted pathways of antibiotics.

Penicillins antibiotics: Discovery, Mode of action, SAR, Penicillins and semi-synthetic penicillins, problems of sensitivity to acids, β-Lactamases and narrow spectrum of activity, Synthesis of oxacillin, cloxacillin, ampicillin, amoxycillin, carbenicillin and carfecillin.

**UNIT II: ANTIBIOTICS-2**

β-Lactamase inhibitors: clavulanic acid, olivanic acid.

Cephalosporins: Classification, Mode of action, SAR, Synthesis of cephalosporin-C, recent advances of fourth generation cephalosporins.

Sulfanilamides: Classification, Mode of action, Synthesis of Sulfathiazole, sulfadiazine, sulfacetamide

**UNIT III: ANTIBIOTICS-3**

Macrolides: Classification, Mode of action, erythromycin, azithromycin, recent developments, Synthesis of chloramphenicol.

Quinolones: Structure and classification, Mode of action, Synthesis of nalidixic acid, ciprofloxacin.

**UNIT IV: ANTI-INFLAMMATORY AGENTS**

Anti-inflammatory agents: Classification, Mode of action, COX-2 inhibitors, Synthesis of celecoxib, valdecoxib, aspirin, phenbutazone, mefanamic acid, indomethacin, piroxicam, diclofenac, Naproxen.

#### Suggested Readings:

1. G. L. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, 2013.
2. J. N. Delgado and W. A. Remers, Wilson and Gisvold’s Text Book of Organic Medicinal and Pharmaceutical Chemistry, Lippincott-Raven, 2010.
3. W. O. Foye, Foye's Principles of Medicinal Chemistry, Lippincott Williams & Wilkins; 6th edition, 2007.
4. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, Academic Press, 2004.
5. M. E. Wolff, Burger’s Medicinal Chemistry and Drug Discovery, Vol. 1, Ed. M E Wolff, John  Wiley, 1995.

**GENERIC ELECTIVE COURSES**

**(GEC)**

**ELECTIVE COURSE OFFERED BY THE DEPARTMENT TO STUDENTS OF OTHER DEPARTMENTS** **SEMESTER-I**

Course Name - Chemistry of Materials

**Course Code - SBS CH 010101 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*Students of GEC come from various backgrounds (social science, science and humanities). This course will try to give a very basic understanding of Chemistry of nanomaterials, porous materials and some photophysical phenomena with focus on energy and environment.*

**UNIT I:** **NANOMATERIALS**

An Introduction, Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials-one dimensional (1D)-two dimensional (2D)-three dimensional (3D) nanomaterials.Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes.Radio- and Microwave Plasma Processes. Flame Aerosol Process. Synthesis of Coated Particles.

**UNIT II: CHARACTERIZATION OF NANOMATERIALS**

Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy.

Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Graphene and Carbon Nanotubes.Nanotubes and Nanorods from Materials other than Carbon, Synthesis of Nanotubes and Nanorods.

**UNIT III: HYBRID MATERIALS**

Coordination Polymers, Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers-Solvothermal/Hydrothermal, Sonochemical, Microwave, Mechanochemical. Charaterization: X-ray diffraction and Spectroscopic Methods. Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery.

**UNIT IV: PHOTOPHYSICAL PHENOMENA**

Interaction of electromagnetic radiation with matter, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence, quantum yield, electronically excited singlet states, life time of electronically excited state, construction of Jablonski diagram, electronic transitions and intensity of absorption bands, types of photophysical pathways, radiationless transitions, fluorescence emission, phosphorescence emission, Fluorescence quenching, chemiluminescence, photochemical reactions.

#### Suggested Readings:

1. S. Kaskel, The Chemistry of Metal-Organic Frameworks, Vol. 1, Wiley-VCH, 2016.
2. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd ed., Wiley-VCH, 2013.
3. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials, World Scientific, 2013.
4. L. R. Macgillivray, Metal-Organic Frameworks: Design and Applications, Wiley, 2010.
5. W. D. Jr. Callister and D. G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, John Wiley and Sons, 2012.
6. K. K. Rohatgi and K. K. Mukherjee; Fundamentals of Photochemistry, 3rd ed. New Age International (P) Ltd., 2014.

SEMESTER-I

Course Name - Basic Concepts in Chemistry

**Course Code - SBS CH 010102 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide the basic concepts in Chemistry to the Students of other Department. At the end of this course, students will learn about the basic knowledge of inorganic, organic and physical chemistry.*

**UNIT І: THE PERIODIC TABLE-HISTORY AND DEVELOPMENTS**

Overview of the periodic system, discoverers of the periodic system, quantitative relationships among the elements and origin of periodic table, the acceptance of Mendeleev’s periodic table, Moseley’s law and periodic table, radioactivity, atomic number and isotopy, transuranium elements, newly discovered elements and completion of periodic table.

**UNIT II: INTRODUCTION TO INORGANIC CHEMISTRY**

History of inorganic chemistry, definition and contrast with organic chemistry, distribution of elements on earth, atomic structure and simple bonding theory, symmetry and its applications, molecular orbitals : heteronuclear diatomic and larger molecules, acid-base and donor accepter chemistry, coordination chemistry : history and modern aspects, organometallic chemistry : reactions and catalysis, bioinorganic chemistry.

**UNIT III: INTRODUCTION TO ORGANIC CHEMISTRY**

Generation, Structure, stability & reactivity of carbocation, carbanions, free radicals &carbene.R & S and E –Z nomenclature of Chiral molecules, Aromaticity of benzenoid and non-benzenoid compounds (Huckel rule), Aldol condensation, Knoevenagel, pinacol-Pinacolone rearrangement.

**UNIT IV: INTRODUCTION TO PHYSICAL CHEMISTRY**

Brief resume of first and second law of thermodynamics. Entropy changes in reversible and irreversible processes; Variation of entropy with temperature, pressure and volume, Entropy concept as a measure of unavailable energy, Free energy functions and their significance, Criteria for spontaneity of a process; Partial molar quantities (Free energy, volume heat content ), Gibb`s-Duhem equation; Clausius-Clapyeron equation, Law of mass action and its thermodynamic derivation. Third law of thermodynamics (Nernst heat theorem, determination of absolute entropy, unattainability of absolute zero) and its limitation.

**Suggested Readings:**

1. G. E. Rodgers, Descriptive Inorganic, Cordination and Solid State Chemistry, 3rd ed., 2009.
2. E. R. Scerri, The Periodic Table: Its Story and its Significance, 2008
3. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd ed., 2005.

SEMESTER-I

Course Name - Chemistry for Biologists

**Course Code - SBS CH 010103 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To understand some basic concepts of chemistry important for biologists in addition to acquire the knowledge of UV-vis., IR and 1H-NMR spectroscopy.*

*At the end of this course, students will understand the basic concepts of chemistry like mole concepts, preparation of solutions, role of H-bonding in biology, stereochemical aspects of organic compounds, thermodynamics, kinetics of reactions, and equilibrium based concepts. They would also learn about the basics of the spectroscopic techniques like UV-vis., IR and 1H-NMR and their application in the characterization of small organic compounds.*

**UNIT I: SOME BASIC TERMS AND CONCEPTS**

Mole concept and Stoichiometry. Solution and different methods of expressing the concentration of a solution. Chemical bonds: Ionic, covalent, coordinate and metallic bonds. Shapes of the molecules, Polarized chemical bonds and polarity in the molecules. Intermolecular forces: Dispersion, dipole-dipole, hydrogen bonds, ion-dipole forces and their effect on the properties of the compounds. Biological implications of hydrogen bonding. Problems based on given topics.

**UNIT II: STEREOCHEMISTRY**

Isomerism: Introduction, Formula writing, Structural and stereo isomerism, Conformations: analysis of ethane, n-butane, cyclohexane and its derivatives, Configurational isomerism, Geometrical and optical isomerism. Symmetry and chirality in the molecules having one or more than one chiral center, R & S, D & L, threo and erythro nomenclature, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective reactions. Problems based on given topics.

**UNIT III: CONCEPTS OF PHYSICAL CHEMISTRY**

Thermodynamics: Change in Internal energy, enthalpy, free energy and entropy; Endothermic and exothermic processes, Exergonic and endergonic processes, Coupled biological processes,

Chemical Kinetics: Reaction rate and rate constant, Catalysts and catalysis, Enzymes as catalysts, Kinetics of enzyme catalysed reactions, Enzyme inhibition.

Chemical equilibrium: Equilibrium, equilibrium constant, Le Châtelier's principle and factors affecting the principle, Aqueous Equilibria: Introduction, importance in biology, pH and pH control, Buffers and their importance.

**UNIT IV: SPECTROSCOPIC TECHNIQUES**

Overview of spectroscopy.

Ultraviolet and visible (UV-vis) spectroscopy: Introduction, Principle and selection rules of UV phenomenon, Various electronic transitions, Beer-Lambert law, presentation of spectrum, effect of solvents on electronic transitions, ultraviolet bands for carbonyl compounds and unsaturated carbonyl compounds. Fieser-Woodward rules for conjugated dienes.

Infrared Spectroscopy: Introduction, Principle and selection rules of IR spectroscopy, Hookes law, Characteristic vibrational frequencies of organic compounds. Overtones, combination bands and fermi resonance. Factors affecting the vibrational frequencies.

NMR: Principle, nuclear spin states, nuclear magnetic moments, mechanism of resonance, chemical shifts, diamagnetic shielding, magnetic anisotropy, spin-spin splitting, coupling constant, Discussion on 1H NMR spectra of various simple organic compounds.

#### Suggested Readings:

1. B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co.; 47th Edition, 2017.
2. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Co., 33rd Edition, 2017.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Spectroscopy, Cengage Learning India Private Limited; 5th Edition, 2015.
4. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, New Age International Private Limited, 2015.
5. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
6. P. Atkins and J. Paula, Atkins' Physical Chemistry, Oxford University Press; 10th Edition, 2014.
7. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, Oxford University Press, 2012.
8. Morrison, Boyd and Bhattcharjee, Organic Chemistry, 7th Edition, Pearson, 2010.
9. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, Wiley India, 2008.
10. J. Mohan, Organic Spectroscopy: Principles and Applications, 2nd Edition, Narosa Publishing House, 2007.
11. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A., Springer, 2007.
12. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edition, New Age International, 2005.
13. K. J. Laidler, Chemical Kinetics, Pearson Education, 3rd Edition, 1997.
14. W. Kemp, Organic Spectroscopy, Palgrave Macmillan, 1991.
15. P. Sykes, A Guide Book to Mechanism in Organic Chemistry, Longman, 1985.

**SEMESTER-II**

Course Name - Environmental Chemistry

**Course Code - SBS CH 010204 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*The course is designed to  introduce students to the fundamental concepts of analytical techniques environmental chemistry;  provide knowledge about various kinds of quantitative techniques; and introduce computation of analytical results, significant figures, concept of error, precision and accuracy, standard deviation, rejection of doubtful values.*

**UNIT I: FUNDAMENTAL CONCEPTS**

Parameters for monitoring**,** Environmental Divisions**,** Natural Cycles

**UNIT II: CHEMISTRY OF AIR**

* Introduction
* Air Pollutants and their sources
* Toxic effects of Carbon monoxide, Nitrogen Oxide, Sulphur Oxides.
* Acid rain
* Depletion of Ozone Layer
* Particulate matter (PM)
* Smog

**UNIT III: CHEMISTRY OF WATER**

* Water Pollution
* Oxygen demanding waste
* Disease Causing waste
* Synthetic organic compounds and oil pollutants
* Inorganic Pollutant
* Sediments
* Radioactive Materials
* Thermal Pollution

**UNIT IV: WATER AND SOIL POLLUTION**

* Domestic water quality,
* Industrial water quality,
* Trace /Heavy elements in water and their removal,
* Waste water treatment.
* Types of rocks,
* Cause of soil pollution,
* Control of soil pollution

#### Suggested Readings:

1. M. N. Rao, Air pollution, New Delhi: TMH, 2010.
2. G. W. Vanloon, Environmental Chemistry, New York: Oxford, 2010.
3. S. Manahan, Environmental Chemistry, Boca Raton: CRC, 2010.
4. O'Neill, Environmental Chemistry, London: Blackie, 2009.
5. M. Srivastava, Environmental Chemistry, Delhi: Sree, 2009.
6. G. Vanloon, Environmental Chemistry, New York: Oxford, 2009.
7. Levin, Aerosol pollution impact on precipitation. New York Springer, 2009.
8. J. Rogers, Environment and water resources. USA: ASCE, 2007.
9. R. Marcos, Biological waste water treatment in warm climate regions, London: IWA, 2006.
10. J. S. Bali, Bioindustrial Watershed Management, New Delhi: JCS, 2005.
11. S. E. Manahan, "FRONTMATTER" *Environmental Chemistry* Boca Raton: CRC Press LLC, 2000.
12. K. Bucher, Global Climate, Wiley, New York, 1976.
13. J. Heichlen, Atmospheric Chemistry, Academic Press, New York, 1976.
14. A. K. De, Environmental Chemistry, 4th Ed., New Age International (P) Ltd.

SEMESTER-II

Course Name - Chemistry in Everyday Life

**Course Code - SBS CH 010205 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*The course is designed to introduce student about the basic use of chemicals in everyday life. We will make the subject interesting and students can develop his skill towards applied sciences.*

**UNIT I: POLYMERS**

Classification of polymers, mechanism of polymerization, some commonly used polymers and their applications (Synthetic rubber, natural rubber, Teflon, PMMA), High density and low density polymer.

**UNIT II: SOAPS & DETERGENTS**

Chemical composition, constitution and cleaning action of soaps and detergents. Difference between soaps and detergents.

**UNIT III: DYES & PIGMENTS AND FOOD ADDITIVES**

An introduction of dyes and pigments. Colour theory of dyes.

Artificial sweeteners, preservatives, colour additives, rancidity.

**UNIT IV: ELECTROCHEMISTRY**

Cells (primary and secondary), composition of cells, cell reactions, Batteries (Pb-Acid battery), composition of batteries, reactions of the battery, fuel cells, solar cells.

**Suggested Readings:**

1. I. L. Finar, Organic Chemistry, Vol-1, ELBS, 2017.
2. H. K. Moudgil, A Text Book of Physical Chemistry, PHI Publication House, New Delhi, 2015.
3. F. Wold, Macromolecules: Structure and Function, Prentice Hall, 2015.
4. H. R. Alcock and F. W. Lamb, Contemporary Polymer Chemistry, Prentice Hall, 2011.
5. J. M. G. Cowie, Physics and Chemistry of Polymers, Blackie Academic and Professional, 2009.
6. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer Science, Wiley-Eastern, 2008.
7. K. Takemoto, Y. Inaki and R. M Ottanbrite, Functional Monomers and Polymers, 2005.
8. F. W. Billmeyer Jr., Textbook of Polymer Science, Wiley, 1990.
9. V. P. Sharma, Bio-organic Chemistry, Pragati Prakshan, 2004.

**SEMESTER-II**

Course Name - Nuclear and Magnetochemistry

**Course Code - SBS CH 010206 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide the basic knowledge of nuclear and magnetochemistry to the students of other Departments. At the end of this course, students will learn about the basics of nuclear radiations, radiopharmacy and chelation therapy and magnetism.*

**UNIT I: NUCLEAR RADIATION**

Radioactive decay and growth, naturally occurring and artificially produced radioactive substances, Penetration potential, Nuclear binding energy, nuclear emissions, nuclear transformations, kinetics of radioactive decay, bombardment of nuclei, nuclear fission, nuclear fusion, Nuclear explosives, kinetic isotope effects, radiocarbon dating, chemical separation, Szilard–Chalmer’s effect, fuel cycle, radioactive waste and waste management, reactor power control.

**UNIT II: RADIOPHARMACY AND CHELATION THERAPY**

Ionizing radiation, effects of radiation on life, somatic Effects, genetic effects, isotopes used in medicines, dispensing and protection, therapeutic use of radiopharmaceuticals, therapy for hyperthyroidism, boron neutron capture therapy, radiopharmaceuticals for imaging, positron emission tomography , heavy-metal poisoning, chelation, chelation therapy.

**UNIT III: INTRODUCTION TO MAGNETIZATION**

Types of magnetism and temperature dependence of magnetic susceptibility, Curie and Curie-Weiss laws, measurement of magnetic susceptibility, types of magnetism in transition metal complexes, spin orbit coupling, quenching of orbital moment in metal complexes, Temperature independent paramagnetism.

**UNIT IV:** **MAGNETIC EXCHANGE**

reduced magnetization, magnetic hysteresis, spin paired and spin free equilibria in complexes, mechanism of exchange interaction, spin crossover, calculation of magnetic moment, orbital contribution to the magnetic moment, M-M direct interaction and super exchange through small bridges, long-range magnetic interactions, factors affecting the spin exchange in multinuclear species, magnetic properties of polynuclear complexes, magnetic properties of lanthanides, anomalous magnetic moments.

#### Suggested Readings:

1. Gary L. Miessler and Donald, A. Tarr, Inorganic Chemistry, 3rd ed. Pearson, 2018.
2. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rd ed. Willey, 2013.
3. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, Oxford University Press, Oxford, 2006.
4. O. Kahn, Molecular Magnetism, VCH Publishers, INc., Orsay, France, 1993.
5. H. J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern, 1988.

**SEMESTER-III**

Course Name - Green Chemistry

**Course Code - SBS CH 010307 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*To provide the basic knowledge of Green Chemistry to the Students of other Departments. At the end of this course, students will learn about the sustainable development, catalysis and renewable raw materials and use of alternative solvents towards the development of green technology and alternative energy.*

**UNIT I: INTRODUCTION TO GREEN CHEMISTRY**

Green chemistry history, needs and goals. Limitation/Obstacles in pursuit of the goals of green chemistry. Opportunities for next generation designer materials to create safer future. Twelve principles of Green Chemistry and their illustrations with examples.

**UNIT II: GREEN CATALYSIS AND RENEWABLE RAW MATERIALS**

Heterogeneous catalysis: Use of zeolites, silica, alumina, clay, polymers, cyclodextrin and supported catalyst; Phase-transfer catalysis; Biocatalysis using enzymes; Biomass conversion to fine chemicals.

**UNIT III: GREENER SOLVENTS**

Reactions under aqueous medium: Enhancement of selectivity, efficiency and industrial applicability. Ionic liquids; Supercritical fluids; Solvent free reactions in solid and liquid phase; Flourous phase reactions; Alternatives in extraction and chromatography.

**UNIT IV: GREEN TECHNOLOGY AND FUTURE TRENDS IN GREEN CHEMISTRY**

Microwave and Ultrasound assisted reactions; photochemical reactions using sunlight; Flow techniques; combinatorial green chemistry. Green synthesis of ibuprofen and adipic acid (traditional vs green ones).

#### Suggested Readings:

1. F. M. Kerton, Alternative Solvents for Green Chemistry. Royal Society of Chemistry, 2013.
2. M. Lancaster, Green Chemistry: Introductory Text. Royal Society of Chemistry, 2010.
3. R. A. Sheldon, I. Arends and U. Hanefeld, Green Chemistry and Catalysis, 1st ed. Wiley-VCH, 2007.
4. M. A. Ryan and M. Tinnesand, Introduction to Green Chemistry. American Chemical Society, 2003.
5. P. T. Anastas and J. C. Warner, Green Chemistry: Theory and Practice. Oxford University Press, 1998.

**SEMESTER-III**

Course Name - Drug Design and Discovery

**Course Code - SBS CH 010308 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*This course will provide a basic understanding and fundamentals towards drug discovery and development process. At the end of this course, students will learn about the various stages involved in drug discovery & development process and challenges encounter during the course of development of new drug which finally comes into the market, various biological drug targets, mode of actions of antibiotics, cardiovascular, and psychoactive drugs and its chemical synthesis.*

**UNIT I: INTRODUCTION**

***History of drug discovery and targets*:** Introduction, Stages of drug discovery, lead discovery,Recent trends in drug discovery. Validation and diversity of drug targets

***Biological drug targets*:** Drug target identification, Receptors, types, binding and activation, theories of drug receptor interaction, drug receptor interactions, agonists vs antagonists, artificial enzymes, Biopharmaceutical therapies, , Hit to lead, Clinical biomarkers.

**UNIT II: DRUG DESIGN**

***Prodrug design:*** Basic concept, Carrier linked prodrugs/Bioprecursors, prodrugs of functional group, prodrugs to improve patient acceptability, Drug solubility, drug absorption and distribution, site specific drug delivery and sustained drug action. Rationale of prodrug design and practical consideration of prodrug design.

***Combating drug resistance*:** Causes for drug resistance, strategies to combat drug resistance in antibiotics and anticancer therapy, genetic principles of drug resistance.

***Analog Design***: Introduction, classical & non classical, bioisosteric replacement strategies, rigid analogs, alteration of chain branching, changes in ring size, ring position isomers, design of stereo isomers and geometric isomers, fragments of a lead molecule, variation in inter atomic distance

**UNIT III: ANTIBIOTICS AND CARDIOVASCULAR DRUGS**

Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, amoxycillin, cephalosporin, ciprofloxacin. Introductory idea of tetracycline and streptomycin. Introduction and general mode of action. Synthesis of ditiazem, verapamil, methyldopa and atenolol.

**UNIT IV: LOCAL ANTIINFECTIVE DRUGS AND PSYCHOACTIVE DRUGS**

Introduction and general mode of action. Synthesis of furazolidone, naldixic acid, dapsone, isoniazid, ethambutol, gluconazole, chloroquin and primaquin. Introduction, neurotransmitters, CNS depressants, general anaesthgetics, mode of action of hypnotics,sedatives, anti-anxiety drugs, benzodiazopines, buspirone. Antipsychotic drugs–theneuroleptics, antidepressants, butyrophenones. Synthesis of diazepam, alprazolam,phenyltoin and glutethimide.

#### Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Ed., Academic Press, 2014.
2. D. M. Brahmankar and S. B. Jaiswal, Biopharmaceutics and Pharmacokinetics, 2nd ed., Vallabh Prakashan, New Delhi, 2014.
3. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Ed., Oxford University Press, 2013.
4. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2nd ed., Pearson, 2012.
5. Ed. Robert F. Dorge, Wilson and Gisvold’s Text Book of Organic Medicinal and Pharmaceutical Chemistry, 12th Ed., 2010.
6. Ed. M. E. Wolff, Burger’s Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Ed., John Wiley, 2010.
7. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Ed., New Age International, 1999.

SEMESTER-IV

Course Name - Materials and Nuclear Chemistry

**Course Code - SBS CH 010409 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*Students of GEC come from various backgrounds (social science, science and humanities). This course will try to give a very basic understanding of Chemistry of nanomaterials, porous materials, magnetochemistry and nuclear chemistry with focus on energy and environment.*

**UNIT I: NANOMATERIALS**

An Introduction.Nanomaterials and Nanocomposites. Classification of nanomaterials - one dimensional (1D)-two dimensional (2D)-three dimensional (3D) nanomaterials.Gas-Phase Synthesis of Nanoparticles-Physical and Chemical Vapor Synthesis Processes. Characterization of Nanomaterials: X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy.

Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Carbon Nanotubes and Graphene, Nanotubes and Nanorods from Materials other than Carbon.

**UNIT II: COORDINATION POLYMERS**

Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers- Solvothermal / Hydrothermal, Sonochemical, Microwave, Mechanochemical. Charaterization: X-ray diffraction and Spectroscopic Methods. Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery. Zeolitic Metal-Organic Frameworks.

**UNIT III: MAGNETOCHEMISTRY**

Definition, classification of magnetic behaviour; diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, antiferromagnetic compounds, magnetic interactions, mechanism of exchange interaction, spin crossover, spin-orbit coupling, Curie law, Curie-Weiss law, reduced magnetization, magnetic hysteresis, calculation of magnetic moment, orbital contribution to the magnetic moment, anomalous magnetic moments, magnetic susceptibility.

**UNIT IV: NUCLEAR CHEMISTRY**

Nuclear binding energy, nuclear emissions, nuclear transformations, kinetics of radioactive decay, bombardment of nuclei, nuclear fission, nuclear fusion, kinetic isotope effects, radiocarbon dating, chemical separation, Szilard–Chalmer’s effect, effects of radiation on life, radioactivity in medicines.

#### Suggested Readings:

1. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd ed. Pearson, 2018.
2. S. Kaskel, The Chemistry of Metal-Organic Frameworks, Vol. 1, Wiley-VCH, 2016.
3. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley-VCH, 2013.
4. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials, World Scientific, 2013.
5. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rd ed. Willey, 2013.
6. L. R. Macgillivray, Metal-Organic Frameworks: Design and Applications, Wiley, 2010.
7. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, Oxford University Press, Oxford, 2006.
8. O. Kahn, Molecular Magnetism, VCH Publishers, INc., Orsay, France, 1993.
9. H. J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern, 1988.

**SEMESTER-IV**

Course Name - Medicinal Chemistry

**Course Code - SBS CH 010410 GEC 4004**

**Credits: 4**

***Course Objective and Learning Outcomes:***

*This course will provide a basic understanding and fundamentals of Medicinal Chemistry, drug-target actions, process of development of new drugs and regulatory processes of drug approval, intellectual property and drug abuse and misuse. At the end of this course, students from the other Departments will acquire basic knowledge of medicinal chemistry and its importance.*

**UNIT I: FUNDAMENTALS**

Historical development of systems of medicine, Basic chemical and biochemical principles, Key definitions, drug, target, receptors, enzymes, common drugs and their classification, anti-inflammatory drugs, antihistamines, antacids, antibiotics, narcotics, antivirals, and antineoplastics.

**UNIT II: DRUG ACTION**

Chemistry of drug-target interactions, bioavailability, drug absorption, distribution, metabolism, excretion (ADME), pharmacokinetics and pharmacodynamics, toxicity, side effects, lipophilicity and hydrophilicity, blood-brain barrier and its significance, routes of drug administration

**UNIT III: DRUG DESIGN AND SYNTHESIS**

Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), isosterism, bio-isosterism, important chemical principles behind design of drugs, natural products and their uses, chemical synthesis of drugs, drug formulation, drug delivery, photodynamic therapy.

**UNIT IV: DRUGS AND SOCIETY**

Regulatory processes for drug approval, regulatory agencies, intellectual property, patents, drug misuse, drug abuse, abuse of antibiotics, fraud practices in treatment, historically important drugs and vaccines.

#### Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Ed., Academic Press, 2014.
2. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Ed., Oxford University Press, 2013.
3. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2nd ed., Pearson, 2012.
4. Ed. Robert F. Dorge, Wilson and Gisvold’s TextBook of Organic Medicinal and Pharmaceutical Chemistry, 12th Ed., 2010.
5. Ed. M. E. Wolff, Burger’s Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Ed., John Wiley, 2010.
6. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Ed., New Age International, 1999.