M.Sc. (5-Year Int.)

School of Chemistry

(Based on UGC – Learning Outcomes-Based Curriculum Framework)

Vision Statement:

To be the source of knowledge and center of training that imparts a sound foundation in chemical sciences with strong transdisciplinary reach, and spawns original and innovative research in contemporary and futuristic chemical themes.

Mission Statements:

- Providing quality chemical sciences education at masters and doctoral levels
- Conducting fundamental and advanced research in chemical sciences
- Establishing research collaborations with other universities/institutes/laboratories
- Carrying out sponsored research and development projects from international/national government and private partners

Qualification Descriptors (QDs)

Utilizing basic knowledge and laboratory skills gained in chemical and allied sciences to:

QD-1 analyze, interpret and explain chemically and related relevant observations

QD-2 identify critical scientific issues and provide potential resolutions

QD-3 create/cultivate new generations of human resource in chemical and allied sciences

QD-4 formulate innovative and relevant scientific problems and develop solutions

Mapping Qualification Descriptors (QDs) with Mission Statements (MS)

	MS-1	MS-2	MS-3	MS-4
QD-1	3	3	1	1
QD-2	3	3	1	1
QD-3	3	3	2	1
QD-4	3	3	3	3

Program Learning Outcomes (PLOs)

After going through the five years of study, chemistry graduates can use the comprehensive knowledge and skills gained, to:

PLO-1: observe, analyze and interpret scientific phenomena and process

PLO-2: design and develop new molecules/processes with industrial and societal applications

PLO-3: formulate new ideas/concepts in chemical and allied sciences and test them

PLO-4: communicate effectively the principles and practice of science, chemistry in particular

PLO-5: address issues of environment, health and development from a chemical perspective

PLO-6: follow professional ethics in all spheres of activity

PLO-7: function effectively as a member/leader in diverse teams/groups

PLO-8: engage in independent learning in the broadest context of scientific advancement

Mapping of Program Learning Outcomes (PLOs) with Qualification Descriptors (QDs)

	QD-1	QD-2	QD-3	QD-4
PLO-1	**3**	**3**	**2**	**2**
PLO-2	**3**	**3**	**2**	**3**
PLO-3	**3**	**3**	**2**	**3**
PLO-4	**2**	**2**	**3**	**2**
PLO-5	**2**	**2**	**3**	**3**
PLO-6	**1**	**1**	**3**	**2**
PLO-7	**3**	**3**	**3**	**3**
PLO-8	**3**	**3**	**3**	**3**

Course Structure

I Year

I Semester (*23 credits*)

Number	Title	Credit
MA-101	Mathematics I	4
PH-101	Mechanics	4
CY-101	Stoichiometry, solutions and gases	3
SB-101	Environmental studies	3
PH-102	Mechanics lab	1.5
CY-102	Qualitative analysis	1.5
	Biology lab	1.5
	IT lab	1.5
	English	3

II Semester (*19 credits*)

Number	Title	Credit
MA-151	Mathematics II	4
PH-151	Waves, oscillations, sound and light	3
CY-151	Energetics and kinetics	3
SB-151	Introductory biology	3
PH-152	Waves and oscillations, sound and light lab	1.5
CY-152	Quantitative analysis	1.5
	Introductory biology lab II	1.5
	IT lab II	1.5

II Year

III Semester (*18.5 credits*)

Number	Title	Credit
MA-201	Mathematics III	4
PH-201	Electricity and magnetism	4
CY-201	Structural chemistry	3
SB-201	Molecules, genes and information processing	3
PH-202	Electricity and magnetism lab	1.5
CY-202	Physical chemistry lab	1.5
	Molecules and information processing lab	1.5

IV Semester (*21.5 credits*)

Number	Title	Credit
MA-251	Mathematics IV	3
PH-251	Modern physics	4
CY-251	Basic organic chemistry	3
SB-251	Structure and function of macromolecules	3
PH-252	Physics lab IV	1.5
CY-252	Identification of organic compounds lab	1.5
	Biology lab IV	1.5
	*Electives for **4 credits** from:*	4
CY-253	Introductory supramolecular chemistry	(2)
CY-254	Elementary polymer chemistry	(2)
	Any other physics/maths/biology course	

III Year

V Semester (*19 credits*)

Number	Title	Credit
CY-301	Inorganic chemistry	3
CY-302	Organic chemistry: Synthesis and reactions	3
CY-303	Analytical chemistry	3
CY-304	Surface and electrochemistry	3
CY-305	Organic chemistry: Conformation and reactivity	3
CY-306	Organic chemistry lab	2
CY-307	Analytical chemistry lab	2

VI Semester (*18 credits*)

Number	Title	Credit
CY-351	Instrumental methods of analysis	3
CY-352	Industrial and environmental chemistry	3
CY-353	Organic rearrangements and natural products	3
CY-354	Computer programming and numerical methods	3
CY-355	Inorganic chemistry lab	2
CY-356	Industrial chemistry lab	2
CY-357	Open-ended lab	2

IV Year

VII Semester (*18 credits*)

Number	Title	Credit
CY-401	Basic concepts and coordination chemistry	3
CY-402	Physical organic chemistry	3
CY-403	Quantum chemistry	3
CY-404	Inorganic chemistry lab: Quantitative and qualitative analysis	3
CY-405	Organic chemistry lab: Techniques	3
FN-106	Symmetry and mathematics	3

VIII Semester (*21 credits*)

Number	Title	Credit
CY-451	Main group and inner transition elements	3
CY-452	Organic reactions and mechanisms	3
CY-453	Molecular spectroscopy	3
CY-454	Chemical and statistical thermodynamics	3
CY-455	Biological chemistry	3
CY-456	Inorganic chemistry lab: Synthesis	3
CY-457	Physical chemistry lab	3

V Year

IX Semester (*21 credits*)

Number	Title	Credit
CY-501	Spectroscopic methods for structure elucidation	3
CY-502	Advanced organic synthesis	3
CY-503	Chemical dynamics	3
CY-504	Chemical binding	3
CY-505	Advanced inorganic chemistry	3
CY-506	Organic chemistry lab: Synthesis	3
CY-507	Instrumentation and computer applications lab	3

X Semester (*15 credits*)

Number	Title	Credit
CY-551	Chemistry of materials	3
CY-552	Seminar	3
CY-553	Project	3
CY-571 to CY-582	Electives for ***6 credits*** from: (See titles in the Syllabus)	6

Course Code : CY-101
Title of the Course : Stoichiometry, Solutions and Gases

L-T-P : L ~~/ T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): Basic chemistry course

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1: understand the basic atomic structure, subatomic particles involved and nomenclature of the binary ionic, molecular compounds.

CLO-2: understand the basic stoichiometric calculations involved in the chemical reactions and balancing the equations.

CLO-3: understanding the solution chemistry involving the colligative properties and redox reactions. To explain the ideal and non-ideal behavior of solutions.

CLO-4: apply the basic concepts of gas laws in various applications in day to day life.

CLO-5: understanding the basic concepts of colloids and its application in the commercially viable technologies.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	3	1	1	3
CLO-2	3	3	3	2	3	1	1	3
CLO-3	3	3	3	2	2	1	1	3
CLO-4	3	3	3	2	3	3	2	3
CLO-5	3	3	3	3	3	3	2	3

Detailed Syllabus – CY-101

Experimental evidence for the atomic hypothesis. Chemical compounds and their composition - introduction to nomenclature.

Chemical reactions and stoichiometric calculations.

Solution chemistry - electrolytes and non-electrolytes. Colligative properties. Ideal and non-ideal solutions. Reactions in solution - redox, acid-base, precipitation, ion exchange.

Colloids. Properties of gases - Avogadro's hypothesis, the ideal gas law. Kinetic molecular theory.

Gas mixtures. Solubility of gases. Gases at high pressure and low temperatures - critical phenomena.

Reference Books:

- Chemistry by McMurry and Fay
- Physical Chemistry by Peter Atkins and Julio de Paula
- Physical Chemistry by Gilbert Castellan
- Physical Chemistry by Robert G. Mortimer

Course Code : CY-102
Title of the Course : Qualitative Analysis Lab

L-T-P : ~~L / T~~ / P
Credits : 0 – 0 – 1.5

Prerequisite Course / Knowledge (If any): A course on chemistry at higher secondary school level

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the basic concepts of experiments in chemistry

CLO-2 : safely handle of chemicals and glass apparatus and in a chemistry lab

CLO-3 : perform chemical reactions in test tubes

CLO-4 : develop observation skills and interpretation of observations

CLO-5 : identifya few elements in a substance

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	3	2	2	1	1
CLO-2	3	3	3	3	3	2	2	1
CLO-3	1	2	3	3	3	3	2	2
CLO-4	1	2	2	2	3	3	3	2
CLO-5	1	1	1	2	3	3	3	3

Detailed Syllabus (CY-102)

Observation of reactions of common cations and anions.
Semimicro analysis of mixtures and Group separation of cations

Following radicals (anions and cations) analysis will be conducted in this course:

Anions or Acid radicals: Nitrate (NO_3^-), Sulfate (SO_2^-), Nitrite (NO_2^-), Chloride (Cl^-), Bromide (Br^-), Iodide (I^-) Acetate (CH_3COO^-), Carbonate (CO_3^{2-}), Sulphide (S^{2-}), Bromate (BrO_3^-), Iodate (IO_3^-), Phosphate (PO_4^{3-}).

Cation or Basic Radicals: Silver (Ag^+), Lead (Pb^{2+}), Copper (Cu^{2+}), Cadmium (Cd^{2+}), Tin (Sn^{2+}), Iron (Fe^{3+}), Chromium (Cr^{3+}), Cobalt (Co^{3+}), Nickel (Ni^{2+}), Manganese (Mn^{2+}), Zinc (Zn^{2+}), Barium (Ba^{2+}), Strontium (Sr^{2+}), Calcium (Ca^{2+}), Sodium (Na^+), Potassium (K^+), Ammonium (NH_4^+).

Reading materials:

1. Lab manual provided by teacher
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis
3. Advanced Practical Inorganic Chemistry – Gurdeep Raj

Course Code : CY-151
Title of the Course : Energetic and Kinetics

L-T-P : L / ~~T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): NONE

Course Learning Outcomes (CLOs)

CLO-1: understand the basic concept of temperature, pressure, enthalpy entropy, free energy. Evaluate thermodynamic properties of pure substances using PVT equation-of-states.

CLO-2: apply first law of thermodynamics to open and closed systems, apply second law of thermodynamics in analyzing efficiency of heat engines, pumps and refrigerators.

CLO-3: understand relation between chemical potential of substance with mole fraction in ideal mixtures and activity in real mixtures using experimental observations of Raoult's and Henry's law for mixtures. Apply these concepts to understand effect of solute concentration on colligative properties.

CLO-4: understand phase diagrams of pure substances based on phase stability at different pressures and temperatures and predict phase transitions based on thermodynamic changes. Use phase diagrams to predict miscibility in different systems.

CLO-5: understand relation between equilibrium constant and standard Gibbs energy of reaction, concept of standard potential and apply to electrochemical cells, use standard potential to predict thermodynamic properties of chemical reactions.

CLO-6: understand concept of reaction rate, order of reaction, homogeneous and heterogeneous reactions, analyses effect of thermodynamic variables such as temperature on rate of reaction and use Arrhenius relation to interpret experimental data, effect of catalyst on rate of reaction, mechanism and rate laws for unimolecular and chain reactions.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**	**PLO 7**	**PLO 8**
CLO-1	3	1	2	3	1	3	3	3
CLO-2	3	3	3	3	2	3	3	3
CLO-3	3	1	2	3	1	3	3	3
CLO-4	3	3	3	3	1	3	3	3
CLO-5	3	3	3	3	2	3	3	3
CLO-6	3	1	3	3	1	3	3	3

Detailed Syllabus (CY-151)

Thermochemistry - enthalpy and enthalpy change - calorimetry - enthalpies of formation and of reactions.

Entropy and free energy. State functions.

Chemical equilibrium in the gas phase - equilibrium constants and their relation to free energy temperature dependence.

Equilibrium in the aqueous phase - pH, buffers and indicators - complex ions.

Electrochemistry - voltage and free energy - standard potentials Batteries, fuel cells.

Chemical kinetics - reaction rates - effect of concentration and temperatures. Steady state approximation. Reaction mechanism from rate laws.

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Heterogeneous equilibria - adsorption.

Suggested reading: Will be prescribed by the instructor.

Course Code : CY-152

Title of the Course : Quantitative Analysis Lab

L-T-P : ~~L / T~~ / P
Credits : 0 – 0 – 1.5

Prerequisite Course / Knowledge (If any): A practical course on quantitative analysis

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the basics of analytical chemistry and analytical tools.

CLO-2 : realize different types of analyses including titrimetry, gravimetry and colorimetry.

CLO-3 : differentiate redox titration from acid base titration and complexometric titration.

CLO-4 : analyze an unknown sample (e.g., an iron containing natural mineral) quantitatively using / applying their knowledge of titimetry, gravimetry, etc.

CLO-5 : teach the rural people about hardness of water, more specifically, of why pond water from a particular place does not form foam, when cloths are washed with a soap.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	1	2	3	3	2	3	3
CLO-2	3	2	3	3	3	1	2	2
CLO-3	2	3	2	2	2	3	3	3
CLO-4	3	3	2	3	3	3	2	2
CLO-5	2	2	3	3	3	2	3	2

Detailed Syllabus (CY-152)

Titrimetry - acid-base, redox, complexometry.

Gravimetry - determination of water of hydration, estimation of sulphate, chloride, aluminium, manganese, iron, nickel.

Colorimetry - Beer's law, estimation of a metal ion (eg., manganese).

Suggested reading:

Lab manual

Course Code : CY-201
Title of the Course : Structural Chemistry

L-T-P : L / ~~T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): None

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand electronic structures in atoms

CLO-2 : appreciate bonding and shapes of molecules and their consequence in physical properties.

CLO-3 : understand the different intramolecular forces.

CLO-4 : correlate structural and stability aspects of molecules.

CLO-5 : understand the structural aspects of crystals.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs) and Program Specific Outcomes (PSOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	1	2	3	1	2	1	3
CLO-2	3	1	2	2	1	2	2	3
CLO-3	3	2	3	3	2	2	1	3
CLO-4	3	3	3	3	2	2	2	3
CLO-5	3	3	2	2	1	2	1	3

Detailed Syllabus (CY-201)

Electrons in atoms - the orbital concept - shapes and size of atomic orbitals - electron configuration and the periodic table. (4 h)

The chemical bond - ionic and covalent bonding. MO and VB pictures - hybridization, resonance. Bond parameters - energy, polarity, length. (8 h)

Shapes of molecules - VSEPR theory. (4 h)

The hydrogen bond. Intermolecular forces and non-bonded intra-molecular interactions. Molecular conformations. Examples of different structures and their stabilities from tri-atomics to bio-molecules. (6 h)

The solid state - molecular, ionic and metallic crystals. Crystal lattices - unit cells. Common crystal structures. Factors influencing crystal structures in ionic/molecular solids. Allotropes (of carbon and sulphur). Network solids - silicates. (8 h)

X-ray diffraction and elementary treatment of Bragg's law - NaCl and KCl. (6 h)

Suggested reading :
Will be prescribed by the instructor.

Course Code : CY-202
Title of the Course : Physical Chemistry Laboratory

L-T-P : ~~L / T /~~ P
Credits : 0 – 0 – 1.5

Prerequisite Course / Knowledge (If any): CY-101, CY-151, CY-152

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : acquire first-hand experience in experimentally measuring several physical quantities.

CLO-2 : understand the utility of some of the spectroscopic techniques

CLO-3 : learn how conductivity measurements help determination of the end-points of titrations

CLO-4 : calculate several thermodynamic properties of different systems

CLO-5 : measure various kinetic parameters of the chemical reactions

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	3	3	3	3	3
CLO-2	2	2	2	2	2	2	2	2
CLO-3	1	2	2	2	2	2	1	1
CLO-4	3	3	3	3	3	3	3	3
CLO-5	1	2	2	2	2	2	1	1

Detailed Syllabus (CY-202)

1. Molecular weight of a polymer (viscometry)
2. Stoichiometry of a complex (Job's method: colorimetry)
3. Conductometric titrations
4. Heat of solution (calorimetry)
5. Phase diagram of a 2-component system
6. pK_a of amino acid (pH titration)
7. Solubility product
8. Paritition coefficient
9. Rate constant of acid catalysed ester hydrolysis

Suggested reading:

1. Physical Chemistry: A Molecular Approach. D. A. McQuarrie and J. D. Simon, University Science books
2. Physical Chemistry. P. W. Atkins and J. de Paula, Oxford University Press.
3. Physical Chemistry. I. N. Levine, McGraw Hill.
4. Laboratory manual for instructions

Course Code : CY-251
Title of the Course : Basic Organic Chemistry

L-T-P : L / ~~T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): None

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand structural features of different organic compounds in terms of stereo and electronic aspects.

CLO-2 : appreciate different ways of electron movement in organic reactions through formation of reactive intermediates.

CLO-3 : apply curved arrow notation to propose reaction mechanisms.

CLO-4 : analyze the stereochemistry of organic compounds.

CLO-5 : understand the general reactivity of different common organic functional groups.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	2	3	1	1	2	1	3
CLO-2	3	1	2	2	1	2	1	3
CLO-3	3	3	3	3	2	2	2	3
CLO-4	3	3	3	3	2	2	2	3
CLO-5	3	2	2	1	1	2	1	3

Detailed Syllabus (CY-251)

1. Bonding and physical properties of organic molecules (8 h)
Nomenclature of simple organic compounds (acyclic, cyclic). Concept of hybridization, resonance, orbital pictures of bonding (sp3, sp2, sp, C-C, C-N & C-O system). Inductive effect, bond polarization, and polarizability, steric inhibition of resonance. Hückel's rules for aromaticity & antiaromaticity, homoaromaticity. Physical properties of bond distance, bond angles, mp/bp & dipole moment in terms of structure and bonding. Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity.

2. Basic reaction mechanism and intermediates (8 h)
Mechanism classifications - ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism. Reactive intermediates: carbocation (carbenium and carbonium ions), carbanions, carbon radicals, carbenes-structure using orbital picture, electrophilic/nucleophilic behavior, stability, generation and fate (elementary idea)

3. Optical activity and stereochemistry (8 h)
Representation of molecules in saw-horse, Fischer, flying-wedge and Newman formulae and their inter translations, symmetry element and molecular chirality. Configuration: stereogenic unit i) stereocenters: systems involving 1, 2, 3 centers, stereogenicity, chirotopicity, pseudoasymmetric (D/L and R/S) descriptor, threo/ erythro / meso and syn/anti nomenclature. Stereo axis: chiral axis in allenes & biphenyls, R/S descriptor: cis/trans, syn/anti, E/Z descriptors (at C=C and C=N bonds). Optical activity of chiral compounds: specific rotation, optical purity (enantiomeric excess), racemic compounds.

4. Chemistry of organic functional groups (12 h)
Alkanes, olefins, alkynes, halides, alcohols, phenols, ketones, aldehydes, carboxylic acids, ethers, derivatives of carboxylic acids, amines, nitro and cyano compounds; synthesis and basic reactivity with mechanisms.

Suggested Text Books:

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Education.

2. P. Y. Bruice, Organic Chemistry, 4th Edition, Pearson Education.

3. T. W. Graham Solomons and C. B. Fryhle, Organic Chemistry, 10th edition, Wiley.

4. I. L. Finar, Organic Chemistry, Vol-1, 6th edition, Pearson Education.

5. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, Wiley.

Course Code : CY-252
Title of the Course : Identification of Organic Compounds

L-T-P : ~~L / T~~ / P

Credits : 0 – 0 – 1.5

Prerequisite Course / Knowledge (If any): Chemistry at +2 level

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : learn how to handle organic chemicals, glassware and precautions to be taken for safety in a Chemistry lab

CLO-2 : learn to identify specific organic compounds based on functional groups

CLO-3 : learn to separate and purify some organic compounds and measure their physical properties

CLO-4 : apply the concepts to identify specific organic compounds

CLO-5 : apply the concepts to test the purity of organic compounds

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	1	1	3	3	3	1	3
CLO-2	3	1	1	3	1	3	1	3
CLO-3	3	1	1	3	3	3	1	3
CLO-4	3	1	1	3	1	3	3	3
CLO-5	3	1	1	3	3	3	3	3

Detailed Syllabus (CY-252)

Unit 1: Separation and purification of organic compounds - melting point - boiling point.

Unit 2: Characteristic reactions of functional groups. Identification of unknowns - chemical and spectral methods.

Reference Books:

Lab manual

Course Code : CY-253
Title of the Course : Introductory Supramolecular Chemistry

L-T-P : L ~~/ T / P~~

Credits : 2 – 0 – 0

Prerequisite Course / Knowledge (If any): Basic chemistry course

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the noncovalent interactions in simple molecules to supramolecules

CLO-2 : explain how biological systems rely heavily on supramolecular interactions for structures and functional properties

CLO-3 : apply the molecular selectivity principle in host-guest chemistry including neutral, anionic and cationic guests

CLO-4 : apply basic concepts of analytical and spectrocospic methods to host-guest chemistry

CLO-5 : create a new supramolecules via self-assembly approach

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	3	1	1	3
CLO-2	3	3	3	2	3	1	1	3
CLO-3	3	3	3	2	2	1	1	3
CLO-4	3	3	3	2	3	3	2	3
CLO-5	3	3	3	3	3	3	2	3

Detailed syllabus (CY-253)

Unit 1: Basic concepts using chemistry examples Intermolecular interactions and hydrogen bonds

Unit 2: Cation binding hosts, cryptands, crown ethers

Unit 3: Anion binding hosts, single and multi-point recognition

Unit 4: Crystal engineering of solid architectures Self-Assembly in nature and materials

Unit 5: Recent examples from literature

Reference Books:

1. J. W. Steed & J. L. Atwood (2009), Supramolecular Chemistry, 1st Edition, John Wiley
2. G.R. Desiraju (1989), Crystal Engineering. The Design of Organic Solids, Elsevier
3. G. R. Desiraju, J. J. Vittal, A. Ramanan (1989), Crystal Engineering -A Textbook, World Scientific-IISc Press
4. Recent papers from journals and reviews and monographs, etc

Course Code : CY-254
Title of the Course : Elementary Polymer Chemistry

L-T-P : L ~~/ T / P~~
Credits : 2 – 0 – 0

Prerequisite Course / Knowledge (If any): IMSc courses in the I & II semesters

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : Understand the differences between small molecules and macromolecules

CLO-2 : Provide insight into the various classes of monomers and polymers

CLO-3 : Understand and analyze polymer molecular weights and various physical properties

CLO-4 : Apply the basic concept of polymers in designing useful polymer materials

CLO-5 : Apply the polymers for advanced applications.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	2	1	1	3
CLO-2	3	3	3	2	2	1	1	2
CLO-3	3	3	3	2	3	1	1	2
CLO-4	3	3	3	3	2	3	2	3
CLO-5	3	3	3	3	3	3	2	3

Detailed Syllabus (CY-254)

History of macromolecular science. **(1 h)**

Definition of polymer, monomer, repeat unit, polymerization. Classification of Polymers based on source and polymerizations-polymer composition and structure. Nomenclature- IUPAC, Non-IUPAC, structure-based, and trade names. Types of polymers based on their molecular structure (linear, branched, cross-linked, block) and stereochemistry of repeating units (Tacticity in polymers) **(5 h)**

Molecular Weights and Sizes: Solubility parameters, Thermodynamics of mixing, Polymer shape and size, measurement techniques-viscosity, colligative properties, chromatography **(5 h)**

Physical State: Crystalline and Amorphous state, Thermal transitions, Glass-Rubber transition, Mechanical properties- stress-strain behaviour, Elastomer, Fibers and Plastics **(5 h)**

Polymer Synthesis: step, chain and miscellaneous polymerizations, Kinetics of polymerization **(7 h)**

Application of Synthetic Polymers: Materials and Biological importance and uses. **(3 h)**

Suggested Reading:

1. Principles of Polymerization by George Odian
2. Introduction to Physical Polymer Science by L. H. Sperling
3. Polymer Chemistry: An Introduction by M. P. Stevens

Course Code : CY-301
Title of the Course : Inorganic Chemistry

L-T-P : L ~~/ T / P~~

Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): None

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the basics of nuclear chemistry

CLO-2 : understand the basic concepts and roles of acids, bases, buffers and non-aqueous solvents

CLO-3 : correlate structure and functions of some key main group elements and their compounds

CLO-4 : appreciate structure, nomenclature and properties of transition elements and their complexes

CLO-5 : understand organometallic and bioinorganic chemistry

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	2	2	3	3	2	1	2
CLO-2	3	1	2	3	3	2	1	2
CLO-3	3	2	2	3	1	2	1	2
CLO-4	3	2	2	3	1	3	1	2
CLO-5	3	2	2	3	3	3	1	2

Detailed Syllabus (CY-301)

NUCLEAR CHEMISTRY: [6 h]

Origin of the elements - Nuclear stability and nuclear binding energy - Nuclear forces - Nuclear Reactions - Artificial radioactivity - Transmutation of elements - Fission, fusion and spallation - Nuclear energy - Separation and uses of isotopes - Radiochemical methods - Principles of determination of age of rocks and minerals- Radio-carbon dating - Hazards of radiation and safety measures

ACIDS, BASES AND BUFFERS: [3 h]

Arrhenius, Brönsted-Lowry, and Lewis concepts of acids and bases - Factors affecting strengths of acids and bases - Ka, Kb, Kw, pH etc.- Buffers, Henderson's equation - Hydrolysis of salts - Common ion effect

NON-AQUEOUS SOLVENTS: [**3 h]**

Physical properties of a solvent for functioning as an effective reaction medium - Types of solvents and their general characteristics - Reactions in liquid ammonia and liquid sulfur dioxide

CHEMISTRY OF SELECTED MAIN GROUP ELEMENTS: [4 h]

Hydrogen bonds, Hydrates and water clathrates - Hydrides and dihydrogen - Alkali metal solution in liquid ammonia - Complexation of alkali metal ion by crown ether and cryptands, Alkali metal anions. Diborane – structure and bonding - Noble gas compounds

COORDINATION COMPOUNDS AND TRANSITION ELEMENTS: [14 h]

Werner's theory – Nomenclature- Chelates- Stereochemistry of coordination numbers 4, 5 and 6 - Various types of isomerism in coordination complexes- Theories of metal-ligand bonding in transition metal complexes – Effective atomic number concept- Valence bond theory of coordination compounds - Limitations of valence bond theory - Crystal-field theory and crystal-field splitting in octahedral and tetrahedral complexes - CFSE and its calculation in different stereochemistries - Weak field and strong field- Low spin and high spin complexes - Pairing energy - Spin cross-over region - Brief account of transition elements

ORGANOMETALLIC CHEMISTRY: [3 h]

Definition, nomenclature and classification of organometallic compounds- Alkyl and aryls of Li, Al, Hg and Sn- Metal-ethylenic complexes

BIOINORGANIC CHEMISTRY: [3 h]

Essential and trace elements in biological processes- Oxygen transport in myoglobin and haemoglobin- Biological function of alkali metal ions

Suggested Text Books:

F. A. Cotton, G. Wilkinson, P. G. Gauss, Basic Inorganic Chemistry, 3rd Edition, John Wiley, 1995

Course Code : CY-302
Title of the Course : Organic Chemistry: Synthesis and Reactions

L-T-P : L / ~~T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): A course on Basic Organic Chemistry

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the behavior of various functional groups in organic chemistry

CLO-2 : explain how chemical reactions proceed under different conditions

CLO-3 : apply in deriving mechanism of chemical transformations

CLO-4 : apply the known reactions to deduce synthetic methods for the target molecules

CLO-5 : propose possible mechanism for novel transformations

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	3	3	1	1	3
CLO-2	3	3	3	3	3	1	1	3
CLO-3	3	3	3	3	2	1	2	3
CLO-4	3	3	3	3	3	1	2	3
CLO-5	3	3	2	3	2	1	2	2

Detailed Syllabus (CY-302)

Addition to C=C bonds and organometallics (8 h)
Electrophilic addition to C=C bonds: Mechanism, reactivity, regioselectivity and stereoselectivity. Reactions: halogenation, hydrohalogenation, hydration, hydrogenation, epoxidation, hydroxylation, ozonolysis, electrophilic addition to dienes (conjugated dienes and allenes). Cycloaddition.
Radical addition: HBr addition, dissolving metal reaction of alkynes and benzenoid aromatics (Birch).
Organometallics: preparation of Grignard reagent, organo lithium and Gilman cuprates and their reactions, 1,2- and 1,4-additions. Reformatsky reaction.

Chemistry of carbonyl compounds (9 h)
Chemistry of -carbon of carbonyls--hydrogen (pKa of different carbon acids), keto-enol tautomerism, base and acid catalyzed keto-enol tautomerism. Halogenation, haloform reaction, Hell-Volhardt--alkylation, aldol reaction [mixed and directed (metal enolate, enamine)], Michael reaction, Robinson annulation, Knoevenagel condensation, Claisen ester condensation, Dieckmann condensation, Perkin reaction, Stobbe condensation, Darzens reaction, acyloin condensation, McMurry coupling, Wittig reaction.
Malonic and acetoacetic esters: Characteristic reactions of active methylene group, synthetic uses of malonic, acetoacetic and cyanoacetic ester.
Addition of nucleophile to carbonyl adjacent to stereogenic center: Cram and Felkin-Anh model. Umpolung using dithiane.

Reagents for reduction and oxidation: Classical methods. (6 h)
Substitution, and elimination reactions (13 h)

Substitution at sp3 carbon center- S_N1, S_N2 and S_N2' mechanisms), effect of solvent, substrate structure, leaving group and nucleophiles, including ambident nucleophiles (e.g. cyanide & nitrite). Mechanism: E1, E2 and E1cB; reactivity. Substitution involving NGP, relative rate & stereochemical features [systems: alkyl halides, allyl halides, alcohols, ethers, epoxides]. Substitution at sp2 carbon. BAC2, AAC2, AAC1 and AAL1 mechanisms (in connection with acids and esters), nucleophilic substitution (SN1, SN2 NGP) cyclohexane system. Elimination (E2) in cyclohexane system. Stereoselective approach to E1, E2 and E1cB mechanisms; reactivity/ orientation (Saytzeff/Hofmann).
Electrophilic aromatic substitution: mechanism orientation and reactivity. Reaction: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction, chloromethylation, Gatterman, Hoesch, Vilsmeier-Haack reaction, Reimer-Tiemann, Kolbe-Schmidt. Nucleophilic substitution reaction: Addition-elimination reaction. SN1 mechanism, benzyne mechanism.

Suggested Text Books:

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Education.
2. P. Y. Bruice, Organic Chemistry, 4th Edition, Pearson Education.
3. T. W. Graham Solomons and C. B. Fryhle, Organic Chemistry, 10th edition, Wiley.
4. I. L. Finar, Organic Chemistry, Vol-1, 6th edition, Pearson Education.
5. S. N. Ege, Organic Chemistry: Structure and Reactivity, 5th edition, Houghton Mifflin College Div, 2003.
6. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, Wiley.

Course Code : CY-303
Title of the Course : Analytical Chemistry

L-T-P : L / ~~T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): CY-101

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the basics of errors in chemical analysis, more specifically, how to report the analyzed data.

CLO-2 : understand the basic principles of acid-base titrations, redox titrations, precipitation titrations, complexometric titrations and electrochemical analyses.

CLO-3 : understand the basic principles of solvent extractions and diverse chromatographic techniques.

CLO-4 : solve stoichiometric calculations / mathematical problems, related to acid-base titrations, redox titrations, precipitation titrations, complexometric titrations and electrochemical analyses.

CLO-5 : apply this overall knowledge of analytical chemistry to handle industrial, pharmaceutical and biochemistry problems including problems in daily life chemistry.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	1	1	3	2	3	3	2
CLO-2	3	2	1	3	3	3	2	3
CLO-3	2	2	2	3	2	3	2	3
CLO-4	2	2	3	3	2	2	3	3
CLO-5	3	3	3	3	2	3	3	3

Detailed Syllabus (CY-303)

Errors in Chemical Analysis (6 h)

Errors and types - Accuracy and precision, Absolute and relative errors, Determinate (systematic) and indeterminate (random) errors,

Statistical treatment of random errors – source and distribution, sample and populations, mean, deviations and standard deviation. Propagation of errors, criteria for rejection of a data (q-test), significant figure and computation rules for significant figures, method of least squares.

Acid-base Titrations (6 h)

Terminology– equivalence point and end point, primary and secondary standards, reactions used for titrations, molarity and normality, some examples of stoichiometric calculations.

Acid-base titration– Acid-bas indicators, theory of acid base indicators, calculation of pH values at different stages of the acid base titration and titration curve.

Precipitation and Complexometric Titration (6 h)

Precipitation titrations- mohr, volhard and fajans methods with examples and indicator theory.

Complexometric titrations- principle, effect of complexing agents and their advantages, examples including EDTA based titration and titration curve, definition of pM+ (-log M+), Back and blank titration with examples, direct and indirect determinations, masking and demasking with examples

Gravimetric Method of Analysis (4 h)

Gravimetry– principle and use with example, Von weimern theory of relative supersaturation, digestion-ostwald ripening, coprecipitation, post precipitation, precipitation from homogeneous solution, organic precipitants.

Electrochemistry in Analysis (8 h)

Redox titrations – Redox indicators, their use in volumetric analysis, iodometry and iodimetry, example of titration from other redox systems.

Electrochemical methods – electrodes and electrochemical cell, standard electrodes, electrochemical series, glass electrode and pH measurement, electrogravimetry, potentiometric titration, DME and polarography, cyclic voltammetry.

Separation Techniques (8 h)

Solvent extraction, gas-liquid chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC), ion exchange chromatography, gel permeation chromatography.

Suggested reading:

(1) "Qualitative Analysis" – Day and Underwood, 5th edition, Prentice-Hall (1986).

(2) "Fundamentals of Analytical Chemistry" – Douglas A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch, 9th Edition,Cengage Learning(2013

Course Code : CY-304
Title of the Course : Surface Chemistry and Electrochemistry

L-T-P : L ~~/ T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): IMSc courses in the I - IV semesters

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the surface, interface, basic conduction phenomenon

CLO-2 : provide insight into the various classes of reactive surface, isotherms, electrical conduction behavior.

CLO-3 : understand and analyze migrations of ions, isotherms, electrode potentials

CLO-4 : apply the basic concept of surface, interface and electrochemistry for various physical insights.

CLO-5 : apply the electrochemistry concept in designing new cells.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	2	1	1	3
CLO-2	3	3	3	2	2	1	1	2
CLO-3	3	3	3	2	3	1	1	2
CLO-4	3	3	3	3	2	3	2	3
CLO-5	3	3	3	3	3	3	2	3

Detailed Syllabus (CY-304)

Surfaces and interfaces: surface free energy and surface tension, contact angles and wetting, work of adhesion and cohesion, curved interface, Young's equation, capillary action, surfactants and surface pressure, surface excess, Gibbs isotherm, surface double layer and potential. **(6 h)**

Structure of solid surfaces: Adsorption and desorption of molecules, physisorption and chemisorption, Langmuir Isotherm, BET and other isotherms, dissociative adsorption, temperature dependence of adsorption, sticking probability. Surface analytical techniques, spectroscopies (Auger, photoelectron, vibrational) temperature programmed techniques. Surface imaging electron microscopy. **(6 h)**

Reactions at surfaces: heterogeneous catalysis, Langmuir-Hinshelwood and Eley-Rideal mechanisms, activation energy. **(3 h)**

Relevance of surfaces and interfaces: colloids, nanomaterials & biology. **(2 h)**

Conductance and Ionisation: ionic conductance, electrical force, field and flux, molar conductivity, strong and weak electrolytes and their molar conductance, law of independent migration of ions: Kohlrausch's law, Ostwald's dilution law, conductometric titrations. **(4 h)**

Theory of Electrolytic Conductance (qualitative description only): ionic atmosphere, electrophoretic effect - Debye-Hückel-Onsager equation, Effect of high potential gradient (Wien effect) and high frequency (Debye-Falkenhagen effect). **(4 h)**

Migration of Ions: Ionic mobility, drift speed, Transport number and its relation with concentration and ionic mobility, Experimental procedures for measuring transport numbers (Hittorf's rule, Moving boundary method), Abnormal transport numbers: Grotthuss mechanism. **(3 h)**

Ion Activities and Debye-Hückel Theory (qualitative descriptions only): Activity and activity coefficients, Ionic strength, Debye-Hückel limiting law, Debye-Hückel theory for concentrated solution. **(3 h)**

Electrochemical Cells: Daniell Reversible and irreversible cells, cell representations and half-cell reactions, E.M.F., Thermodynamics of electrochemical systems: Nernst equations, varieties of electrodes, standard electrode potential. **(3 h)**

Type of boundary between half cells and Liquid junction potentials, Concentration cells, Applications of EMF measurements- potentiometric titrations, determination of activity coefficient, composition of complex ions, solubility product, measurement of pH and pKa (Hydrogen, Quinhydrone, Glass electrodes), Polarization, Overvoltage **(3 h)**

Application of Electrochemical Cells- Dry cells, Lead Batteries, Alkaline cells (Edison Cell), Fuel cells, Biological energy conversions. **(3 h)**

Suggested readings:

1. Physical Chemistry- P. W. Atkins
2. Electrochemistry – Samuel Glasstone

Course Code : CY-305
Title of the Course : Organic Chemistry: Conformation and Reactivity

L-T-P : L ~~/ T / P~~

Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): A course on basic understanding of reaction kinetics, conformation and heterocycles (Physical Aspects)

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the basics of reaction kinetics and thermodynamics.

CLO-2 : understand conformation of a molecule and how they affect the reactivity.

CLO-3 : understand the basic principles of photochemistry.

CLO-4 : know the photochemical reactions.

CLO-5 : understand the impact of aromatic and heteroaromatic compounds in synthesis.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	2	2	2	1	2	1	3
CLO-2	3	2	2	2	1	2	1	3
CLO-3	3	3	2	2	1	3	1	3
CLO-4	3	3	3	3	3	3	3	3
CLO-5	3	3	2	3	3	3	3	3

Detailed syllabus (CY-305)

Thermodynamic and kinetic principles [11 h]

Reaction thermodynamics: free energy and equilibrium, enthalpy and entropy factors, intermolecular and intramolecular reaction. Heat of hydrogenation and heat of combustion. Application of thermodynamic principle in tautomeric equilibria [keto-enol tautomerism, composition of the equilibrium in different systems (simple carbonyls, 1,3- and 1,2-dicarbonyl systems, phenols, and related systems), substituent and solvent effects]. Reaction kinetics; transition state theory, rate constant and free energy of activation, free energy profile for one step and two step reactions, catalytic reactions, kinetically controlled and thermodynamically controlled reactions, isotope effect, primary kinetic isotopic effect (kH/kD), principle of microscopic reversibility. Crossover experiments.

Conformation and stereochemistry [13 h]

Racemization (through cationic, anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation.
Topicity of ligands and faces; Pro-R, Pro-S, and Re/Si descriptors.

Conformation : nomenclature, eclipsed, staggered, gauche and anti, dihedral angle, torsion angle, energy barrier of rotation, relative stability of conformation on the basis of steric effect, dipole-dipole interaction, H-bonding; conformational analysis of ethane, propane, n-butane, haloethane, 1,2-haloethane, 1,2-glycol, 1,2-halohydrin; invertomerism of trialkylamine.

Cyclic stereochemistry: Baeyer strain theory, conformational analysis: cyclohexane, mono and disubstituted cyclohexane, symmetry properties, and optical activity.

Photochemistry [4 h]

Primary photochemical processes, Jablonskii diagram, photochemical reactions of carbonyl compounds: Norrish type I and II reactions. Photochemistry of olefins: cis-trans isomerism, Paterno-Buchi reaction.

Aromatic and Heterocyclic compounds [8 h]

Naphthalene, anthracene and phenanthrene. Heterocyclic compounds: synthesis, structure, reactivity, orientation and important reactions of epoxide, aziridine, furan, pyrrole, thiophene, and pyridine.

Suggested Text Books:

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Organic Chemistry, 7th Edition, Pearson Education.
2. P. Y. Bruice, Organic Chemistry, 4th Edition, Pearson Education.
3. M. B. Smith and J. March, March's Advanced Organic Chemistry, 6th edition, Wiley, 2007.
4. 5. Jonathan Clayden, Nick Greeves, Stuart Warren: Organic Chemistry 2nd Edition, Oxford, 2014

Course Code : CY-306
Title of the Course : Organic Chemistry Lab

L-T-P : ~~L / T~~ / P
Credits : 0 – 0 – 2

Prerequisite Course / Knowledge (If any): CY-252

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : provide insight into organic chemistry lab

CLO-2 : appreciate the basic concepts related to the synthesis of organic compounds

CLO-3 : apply the basic concepts of new organic compounds based on a fundamental understanding

CLO-4 : practice laboratory safety

CLO-5 : apply different synthetic techniques for the synthesis of organic compounds

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	2	1	1	3
CLO-2	3	3	3	2	2	2	1	3
CLO-3	3	3	3	2	2	2	1	3
CLO-4	3	3	3	3	3	3	2	3
CLO-5	3	3	3	2	3	3	2	3

Detailed Syllabus (CY-306)

Preparation of organic compounds using classical organic reactions such as nitration, bromination, acetylation, condensation and oxidation.
Estimation of selected organic compounds.

Suggested reading:

1. A.I. Vogel, Textbook of Practical Organic Chemistry, 4th edition.
2. Laboratory manual.

Course Code : CY-307
Title of the Course : Analytical Chemistry Lab

L-T-P : ~~L / T~~ / P
Credits : 0 – 0 – 2

Prerequisite Course / Knowledge (If any): Basic analytical chemistry course

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the concentrations, molarity, volumetric and gravimetric methods.

CLO-2 : explain how volumetric and gravimetric analysis are useful to find out a amount of particular cations/anions in Food and other materials.

CLO-3 : apply the various analytical approaches for quantitative measurements.

CLO-4 : apply quantitative concepts to analyze the unknown amount in the samples including drugs to cooking materials.

CLO-5 : create a new quantitative approach from learned analytical approach.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	3	1	1	3
CLO-2	3	3	3	2	3	1	1	3
CLO-3	3	3	3	2	2	1	1	3
CLO-4	3	3	3	2	3	3	2	3
CLO-5	3	3	3	3	3	3	2	3

Detailed Syllabus (CY-307)

Food, Fertilizer and cosmetics analysis

1. Determination of the amount of calcium in milk powder by EDTA complexometric titration.

2. Estimation of iodine in iodized common salt using iodometric titration.

3. Estimation of phosphoric acid in cola drinks (coke, thumps up and Pepsi) by blue phosphomolybdic acid method (spectrophotometry).

4. Analysis of phosphorous (as phosphate) from phosphorous containing fertilizer.

5. Analysis of sulfur (as sulfate) from sulfur containing fertilizer.

6. Gravimetric analysis of aluminum in commercially available deodorants.

7. Preparation of [Ni(NH3)6]2+ and analysis of its nickel content by gravimetric method.

8. Extraction and identification of DNA from green peas.

9. Analysis of kidney stones by permanganometric titration.

10. Determination of hardness of tap water.

Reference Books:

5. Anil J. Elias (2002), A collection of interesting GENRAL CHEMISTRY EXPERIMENTS, Universities Press.
6. (1989), Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn, Orient Longman.
7. Laboratory Manual
8. Papers from Chemical Education Journals.

Course Code : CY-351
Title of the Course : Instrumental Methods of Analysis

L-T-P : L ~~/ T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): None

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : observe and recognize the basics of different instruments design and function (various Mass spectrometry, X-Ray diffraction techniques, UV-IR-Raman-CD, NMR, EPR, atomic absorption/emission spectroscopy) for chemical analysis.

CLO-2 : understand and recognize various electronic/optical/magnetic/electric components of various instruments from a chemical perspective.

CLO-3 : realize the concepts of various instrumental techniques for the analysis of diverse chemical compounds in various forms (crystals/films/powder).

CLO-4 : design a combination of different instrumental techniques to analyses the chemicals.

CLO-5 : understand the importance of design and development of new instrumental techniques for societal needs.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	2	2	2	2	1	1	3
CLO-2	3	2	2	2	3	1	1	3
CLO-3	3	3	2	2	2	1	1	3
CLO-4	3	3	3	3	3	1	3	3
CLO-5	2	3	3	3	3	3	3	3

Detailed Syllabus (CY-351)

Introductory treatment of the following techniques, including basic instrumentation and illustrative applications from all branches of chemistry.

Absorption and emission spectroscopy (8 h)

Atomic spectroscopy – instrumentation of AAS, AES, ICP-MS/AES Molecular spectroscopy – instrumentation of UV-Vis, IR and CD spectroscopy

Mass spectrometry (8 h)

Basic treatment of ionization methods – FD, EI, CI, ESI, MALDI, FAB Mass analyzers – sectors, quadruple, TOF, ion trap, Detectors – electron multiplier, Faraday cup, array detectors Applications – small molecules, inorganic complexes, polymers, proteins

NMR spectroscopy (8 h)

Basics – Larmor precession, resonance absorption, magnetic fields, shielding and chemical shifts, chemical equivalence, relaxation processes Solution state (^{1}H, ^{13}C) and solid state techniques Instrumentation – block diagram, magnets, sample probe, RF generation and detection,

FT NMR/ESR spectroscopy (6 h)

Introduction – g factor, hyperfine coupling, fine structure Instrumentation – microwaves, waveguides, magnetic field modulation Applications – free radicals, metal complexes, reaction intermediates

Diffraction Techniques (8 h)

X-ray diffraction – Crystal lattices and Miller planes, Bragg condition, Ewald's sphere Instrumentation – X-ray sources including synchrotron, filters, detectors including CCD ,Powder diffraction techniques – Debye-Scherrer Single crystal data collection – 4-circle method, Laue method, rotating crystal

Reading material:

1. Undergraduate Instrumental Analysis by James W. Robinson, Eileen M. Skelly Frame, George M. Frame II, Sixth Ed, Marcel Dekker, New York, 2005.
2. . Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, Fourth Ed., Brooks/Cole Thomson Learning 2009.
3. 3. Physical Chemistry by Peter Atkins and Julio de Paula, 9th Ed., Oxford University Press, 2010.
4. 4. Mass Spectrometry of Inorganic, Coordination and Organometallic Compounds by William Henderson and J. Scott McIndoe, John Wiley & Sons Ltd, 2005.

Course Code : CY-352
Title of the Course : Industrial and Environmental Chemistry

L-T-P : L ~~/ T / P~~
Credits : 3 – 0 – 0

Prerequisite Course / Knowledge (If any): basic chemistry knowledge

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : provide insight into fuel classification

CLO-2 : provide insight into petrochemical and catalysis

CLO-3 : appreciate the industrial organic synthetic processes

CLO-4 : appreciate the chemistry behind essential commodities such as soap, polymer, cement etc..

CLO-5 : provide insight into Green Chemistry and synthesis

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	3	1	1	3
CLO-2	3	3	3	2	3	1	1	3
CLO-3	3	3	3	2	2	1	2	3
CLO-4	3	3	3	2	3	3	1	3
CLO-5	3	3	3	3	3	3	1	3

Detailed Syllabus (CY-352)

Fuels: Classification, solid, liquid, and gaseous forms. Occurrence, purification, composition and calorific value **[2 h]**

Petrochemicals and petroleum products **[4 h]**

Catalysis: Relevant to industrial applications. **[2 h]**

Industrial organic synthesis: Synthesis of methanol, ethanol, acetic acid, acetone, glycerol and ethyl acetate etc **[3 h]**

Silicates, glass, ceramics, refractories, cement. **[3 h]**

Fertilizers: Nitrogenous and phosphate fertilizers. **[3 h]**

Industrial acids and bases **[2 h]**

Active pharmaceutical intermediates and drugs **[2 h]**

Polymers, plastics, rubber, synthetic fibers, and paper [**4 h**]

Soaps and detergents [**2 h**]

Insecticides and pesticides [**2 h**]

Dyes, paints and pigments [**2 h**]

Tanning of leather [**2 h**]

Environmental aspects: Global warming, acid rains, smog, ozone depletion, toxic metals, carcinogens. Green chemistry [**3 h]**

Reading material

1. P. J. Chenier, Survey of industrial chemistry, 3rd Edition, Kluwer Academic/Plenum Publishers, 2002.
2. B. K. Sharma, Industrial Chemistry including Chemical Engineering, Krishna Prakashan Media (p) Ltd, 2006.
3. S. E. Manahan, Fundamentals of Environmental Chemistry, 3rd edition, CRC press, 2008.

Web resource: http://chemistry.uohyd.ac.in/~CY352/

Course Code : CY-354
Title of the Course : Computer Programming and Numerical Methods

L-T-P : L / T / P
Credits : 2 – 0 – 1

Prerequisite Course / Knowledge (If any): basic graduation level knowledge of chemistry and mathematics mandatory. Knowledge of programming language is plus point, but not mandatory.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : understand the basics of different numerical methods and equip them to apply numerical methods to obtain approximate solutions to mathematical problems.

CLO-2 : write simple, error free computer programs and equip them to develop simple numerical algorithms.

CLO-3 : learn the basics of Fortran programing language and acquire the skill to implement numerical methods in Fortran language.

CLO-4 : learn the basics of python programming language and acquire the skill to implement numerical methods in python language.

CLO-5 : apply the acquired skills to design new algorithms and write efficient computer programs and master the art of scientific programming.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	2	2	1	3
CLO-2	3	3	3	2	2	2	1	3
CLO-3	3	3	3	2	2	3	3	3
CLO-4	3	3	3	3	2	3	3	3
CLO-5	3	3	2	3	3	3	3	3

Detailed Syllabus (CY-354)

Computer: brief description of Hardware & Software. Programming in FORTRAN: Program design (algorithm), organization of program, data types and integer constants, complex constants, logical constants, variables, implicit and explicit data typing, expressions and hierarchy of operations, mix-mode arithmetic, library functions, input/output specification, formatting, unconditional transfers, conditional statements and constructs, GO TO/ IF statements, relational operators, block if structure, else if construct, do loops, nesting, variables and arrays, parameter/data statements, common blocks, read/write by opening files, subroutines and construction of large program.

Programming Laboratory (Linux OS, vi editor): Students are instructed to write programs of the numerical methods taught.

Numerical Methods: Taylor's theorem, Expansion of functions, Remainder, Mean value and Extreme value theorems, Discrete average value theorem. Numerical Differentiation (first, second and higher derivatives)- Truncation and Round-off errors, Step-size dilema, Difference table (Pascal's triangle). Numerical Integration- Riemann sum, Quadrature rule, Interpolating polynomials (Lagrange's), Weights, Mid-point, Trapezoidal, Simpson's rule of integration, Adams' Predictor-Corrector method. Roots of equations- Newton-Raphson and Secant methods, Bisection and False-point methods, Bracketing method. Numerical solution of ordinary differential equations- Initial value problems, Euler's method, Taylor and Runge-Kutta methods, Modified Euler and Huen's method, Error estimates. Curve fitting- Least square fit algorithm, Monotone and convex data. Linear systems- Forward, Backward substitution, LU- factorization, pivoting (only basics), Gaussian Elimination, Gauss-Jordan Elimination, Jacobi and Gauss-Seidel methods. Eigenvalue problems. Statistical analysis of data.

Suggested reading:

1. Numerical Analysis: a Mathematical Introduction, M. Schatzman, Oxford University Press.
2. Numerical Methods in Fortran, J. M. McCormick and M. G. Salvadori, Prentice Hall of India Private Limited.
3. Numerical Analysis, R. L. Burden and J. D. Faires, Brooks/Cole Thomson Learning. 4. An Introduction to Numerical Methods and Analysis, J. F. Epperson, John Wiley and Sons, Inc.
5. Numerical Analysis: A Practical Approach, M. J. Maron, Macmillan Publishing Co. Inc.
6. Introduction to Numerical Analysis, F. B. Hildebrand, McGraw Hill Book Company, New York.
7. Numerical Methods for Engineers, D. V. Griffiths and I. M. Smith, Oxford University Press.
8. Fortran 77 and Numerical Methods, C. Xavier, New Age International Publishers.
9. Computer Programming in Fortran, V. Rajaraman, PHI Learning Private Limited.
10. Numerical Analysis and Computational Programming, S. A. Mollah, Books and Allied (P) Ltd.
11. Numerical Recipes in Fortran: The art of Scientific Computing, W. H. Press, S. A. Teukolsky, W. T. Vellerling and B. P. Flannery, Cambridge University Press.

Course Code : CY-355
Title of the Course : Inorganic Chemistry Laboratory (2 credits)

L-T-P : ~~L / T~~ / P
Credits : 0 – 0 – 2

Prerequisite Course / Knowledge (If any): NIL

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : synthesize Werner-type coordination compounds

CLO-2 : analyze and understand the structure of the synthesized compounds

CLO-3 : develop skills of growing single crystals suitable for diffraction technique

CLO-4 : design and synthesize main group metal based compounds

CLO-5 : utilize the skills acquired for designing and synthesizing novel molecular frameworks.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	3	1	1	3
CLO-2	3	3	3	2	3	1	1	3
CLO-3	3	3	3	2	2	1	1	3
CLO-4	3	3	3	2	3	3	2	3
CLO-5	3	3	3	3	3	3	2	3

Detailed Syllabus (CY-355)

Synthesis of a variety of Inorganic Compounds:

Complexes of 3d metal ions and rare earth ions and main group compounds by using common experimental techniques.

Study of the related literature (UG level).

Preparation of Scientific Reports.

Course Code : CY-356
Title of the Course : Industrial Chemistry Laboratory

L-T-P : ~~L / T~~ / P
Credits : 0 – 0 – 2

Prerequisite Course / Knowledge (If any): IMSc courses in the I – V semesters

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : provide insight into industrial chemistry

CLO-2 : appreciate the basic concepts related to the industrial chemistry

CLO-3 : apply the basic concepts of new industrial chemicals based on a fundamental understanding

CLO-4 : understand the synthesis of industrial compounds

CLO-5 : apply different synthetic techniques for synthesis of industrial compounds

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	2	2	2	1	3
CLO-2	3	3	3	2	2	2	1	3
CLO-3	3	3	3	2	2	2	1	3
CLO-4	3	3	3	3	3	3	2	3
CLO-5	3	3	3	2	3	3	2	3

Detailed Syllabus (CY-356)

Experiments based on major industrial processes, operations and methods of analysis of Industrial Chemicals and materials.

1. Synthesis of allobarbital
2. Synthesis of warfarin
3. Synthesis of paracetamol
4. Synthesis of oil of wintergreen
5. Synthesis of indigo and dyeing of cloth
6. Extraction of casein from milk
7. Estimation of iron in tablet
8. Extraction of curcumin from turmeric
9. Preparation of soap
10. Laboratory preparation of shaving gel
11. Preparation of nylon 6 6
12. Preparation of super absorbent polymer and exploration of its properties
13. Synthesis of molecular sieve – zeolite X and cobalt exchange reaction with it
14. Synthesis of biodiesel

Course Code : CY-357
Title of the Course : Open-ended Laboratory

L-T-P : ~~L / T~~ / P

Credits : 0 – 0 – 2

Prerequisite Course / Knowledge (If any): Basic chemistry knowledge

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1 : learn how to approach a research problem

CLO-2 : direct the student to independent thinking

CLO-3 : learn frontier areas of chemical research

CLO-4 : apply the ideas to design new experiments

CLO-5 : learn to handle few sophisticated equipment

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
CLO-1	3	3	3	3	3	3	3	3
CLO-2	3	3	3	3	1	3	3	3
CLO-3	3	3	3	3	3	3	3	3
CLO-4	3	3	3	3	3	3	3	3
CLO-5	3	3	3	3	3	1	3	3

Detailed syllabus (CY-357)

In this course, students are assigned a task and are expected to try various approaches to solve it. For example, enzyme kinetics studies, study of the gel-fluid phase transition of lipids using fluorescence, organic synthesis and synthesis of giant inorganic metal oxide clusters and their reactions. The students are assessed based on the practical skills in the lab, originality and the written report at the end of the course. Since the course in the nature of short projects, the experiments chosen may vary from year to year.

Reference Books:

Lab manual, provided by the course instructor