ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF APPLIED & PURE SCIENCES

(RSAPS)

DEPARTMENT OF CHEMISTRY

COURSE STRUCTURE & SYLLABUS

(BASED ON NATIONAL EDUCATION POLICY 2020)

FOR

M.Sc. CHEMISTRY

STRUCTURE OF THE SYLLABUS FOR 2 YEAR PG PROGRAMME

SCHOOL NAME - ROYAL SCHOOL OF APPLIED AND PURE SCIENCES (RSAPS)
DEPARTMENT NAME - CHEMISTRY
PROGRAMME NAME - M.Sc. in CHEMISTRY

1st SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
CHY014C101	Physical Chemistry I	400	4	4-0-0
CHY014C102	Organic Chemistry I	400	4	4-0-0
CHY014C103	Inorganic Chemistry I	400	4	4-0-0
CHY014C104	Quantum Chemistry	400	4	4-0-0
CHY014C115	Inorganic Chemistry Lab	400	4	0-0-8
SWAYAM CODE 1	Swayam 1	400	3/4/5	
	TOTAL CREDIT FOR 1st SEMESTER		**20** + 3/4/5	
2nd SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
CHY014C201	Physical Chemistry II	400	4	4-0-0
CHY014C202	Organic Chemistry II	400	4	4-0-0
CHY014C203	Inorganic Chemistry II	400	4	4-0-0
CHY014C204	Analytical Chemistry	400	4	4-0-0
CHY014C215	Organic Chemistry Lab	400	4	0-0-8
SWAYAM CODE 2	Swayam 2	400	3/4/5	
	TOTAL CREDIT FOR 2nd SEMESTER		**20** + 3/4/5	
TOTAL CREDIT FOR 1st YEAR = 40 + 6/8/10				
3rd SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
CHY014C301	Spectroscopy I	500	4	4-0-0
CHY014C302	Biochemistry & Bioinorganic Chemistry	500	4	4-0-0
CHY014C303	Environmental & Green Chemistry	500	4	4-0-0
CHY014C314	Physical Chemistry Lab	500	4	0-0-8
CHY014C325	Project -I	500	8	0-0-0
SWAYAM CODE 3	Swayam 3	500	3/4/5	
	TOTAL CREDIT FOR 3rd SEMESTER		**24** + 3/4/5	
OR 3rd SEMESTER (For students with 3rd and 4th Semester Research)				
CHY014C321	**RESEARCH PROJECT – PHASE I**	**500**	**24** + 3/4/5	**0-0-0**
4th SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
	Dissertation (students with research in 4th Sem)			
(for 'Coursework only' in lieu of Research)				
CHY014C401	Spectroscopy II	500	4	4-0-0
CHY014C402	Chemical Kinetics & Catalysis	500	4	4-0-0
CHY014C403	Heterocyclic Compounds & Medicinal Chemistry	500	4	4-0-0
CHY014C404	Organometallic Chemistry & Catalysis	500	4	4-0-0
CHY014C426	Project -II	500	12	0-0-0
SWAYAM CODE 4	Swayam 4	500	3/4/5	
OR 4th SEMESTER (For students with 3rd and 4th Semester Research)				
CHY014C426	**RESEARCH PROJECT – PHASE 2**	**500**	**28** + 3/4/5	**0-0-0**
TOTAL CREDIT FOR 2nd YEAR = 52+ 6/8/10				

SYLLABUS (1st SEMESTER)

Subject Name: Physical Chemistry I	**Level = 400**	**Subject Code: CHY014C101**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objective of **Physical Chemistry I** is to understand the concept of statistical thermodynamics & ion-solvent interactions and applications of phase rule.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl. No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Define** and gain the knowledge from laws of thermodynamics to solve the complex problems of physical chemistry	BT1
CO2	**Explain** the concept of thermodynamical parameters and their importance to interpret the spontaneity of reaction.	BT2
CO3	**Apply** the knowledge of chemical kinetics and analyze chemical reactions and reaction mechanism.	BT3
CO4	**Analyze** and **Explain** different energy exchange processes.	BT4 & BT5

Detailed Syllabus:

Modules	**Topics & Course content**	**Periods**
I	**Classical Thermodynamics** Thermodynamics of real gases and gas mixtures, Fugacity, relation between fugacity and pressure, variation of fugacity with temperature and pressure, non-ideal solutions, Activity, dependence of activity on temperature and pressure, Fugacity coefficients and activity coefficients– different scales of activity coefficients. Non-equilibrium thermodynamics: Review of basic concepts of force, flow and entropy production, rate of entropy production, entropy production in chemical reactions, coupled forces and flows and phenomenological relations; Onsager reciprocal relations.	**18**

II	**Statistical Thermodynamics** Statistical mechanics of systems independent particles- Maxwell Boltzmann distribution law, entropy and probability, calculation of thermodynamic properties for independent particles-molecular partition functions, physical significance of partition function, evaluation of partition function-translational, rotational, vibrational and electronic partition functions. Statistical interpretation of work and heat, thermodynamic properties of ideal monoatomic and diatomic molecules-Suckur-Tetrode equation, calculation of partition functions, thermodynamic function, principles of equipartition.	**18**
III	**Dynamic Electro-chemistry** Ion size factor and ion-solvent interactions–The Born model. Thermodynamic parameters of ion-solvent interactions–structural treatment, the ion-dipole model–its modifications, ion quadrupole and ion–induced dipole interactions. Primary solution–Determination of hydration number, compressibility method and viscosity mobility method. Debye-Húckel theory of ion-ion interactions–derivation, validity and limitations, Debye-Huckel-Onsager treatment and its extension to concentrated solutions.	**18**
IV	**Phase equilibrium** Phase equilibrium of two-component system, phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Application of Gibbs phase rule to three component systems – triangular plots–water-acetic acid–chloroform system. Binary solutions: Gibbs-Duhem-Margules equation and its applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, partial miscibility of liquids.	**18**
Total		**72**

Text Books:

1. *Physical Chemistry;* Atkins, P.W. and Paula, J. de; 10th edition; 2014; Oxford University Press
2. *Principles of Physical Chemistry*; Puri, B.R.; Sharma, L.R.; Pathania, M.S.; 47th edition; 2016; Vishal Publishing Company

Reference Books:

1. Glasstone, S.; *Textbook of Physical Chemistry;*11th edition;2011; VanNostrand company.

2. Atkins, P.W. and Paula, J. de; *Elements of Physical Chemistry;* 6th edition; 2012; Oxford University Press.
3. Kapoor, K. L.; *A textbook of Physical chemistry*; 6th edition,; 2011; Macmillan, India Ltd.
4. Bokris, J.A. and Reddy, A.K.N; *Modern Electrochemistry*; Vols. 1&2; Kluwer Academic Publishers
5. Levine, I.; *Physical Chemistry;* 6th edition; 2008; McGraw–Hill Science.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (1st SEMESTER)

Subject Name: Organic Chemistry I	**Level = 400**	**Subject Code: CHY014C102**
L-T-P-C – 4-0-0-4	**Credit Units:4**	**Scheme of Evaluation: T**

Objective: The objective of **Organic Chemistry I** are to provide a thorough knowledge of kinetics of organic reactions, bonding of organic molecules, classifications of reaction with mechanism, stability and reactivity of reaction intermediates, stereochemistry and conformational analysis of molecules.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Relate** the stereo chemical and conformational aspect of molecules	BT1
CO2	**Explain** the three dimensional orientation of molecules and its effect on molecular reactivity	BT2
CO3	**Apply** the concept of organic chemistry to understand the bond formation and bond breaking of new organic molecule.	BT3
CO4	**Analyze** the reaction mechanism to develop strategy of a new reactions	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Reaction mechanism** Structure and Reactivity: Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, Hammond postulate, Curtin-Hammett principle, transition states and intermediates, methods of determining mechanisms, isotopic effects. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity. The Hammett equation and linear free energy relationship (sigma-rho) relationship, Taft equation.	**12**
II	**Stereochemistry and conformational analysis** Acyclic systems upto 4 chiral centres, compounds with asymmetric carbons in branched chain, Klyne-Prelog conformational terminology. Axial chirality, planer chirality. Conformation of cyclic systems: cyclohexene, cyclohexanone, decalin. Optical activity in absence of chiral carbon (biphenyls, allenes and spiranes). Conformational effect on reactivities and physical properties of molecules.	**12**
III	**Bonding in organic compounds** Aromaticity: Concept of Aromaticity, non-aromaticity and antiaromaticity, pseudo aromaticity, homo aromaticity, NMR in aromatic character, Huckel's rule and its limitations, non-benzonoid compounds (aromaticity), alternate and non-alternate hydrocarbons, annulenes, fulvenes, fulvalenes, azulenes, fullerenes. Supramolecular chemistry: Addition compounds: Crown ether complex, Cryptands. Inclusion compounds, Cyclodextrins, Catenanes, Rotaxanes and their applications.	**12**
IV	**Disconnection approach** An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter conversion, importance of order of events in organic synthesis, one group C-X and two group C-X disconnections, chemo selectivity, reversal of polarity, cyclisation reactions, amine synthesis. Protecting groups: Principle of protection of alcohol, amine, carbonyl and carboxyl groups. One group C-C disconnection: alcohol, carbonyl compounds, regioselectivity. Use of acetylene in organic synthesis. Diels –Alder reactions, Michael addition and Robinson annulation.	**12**
Total		**48**

Text books:

1. *Advanced organic chemistry: Reactions, mechanism and structure*; March Jerry; 7th edition; John Wiley; 2015; United States of America.

2. *Advanced organic chemistry*; Carey F. A. and Sundberg R. J.; 5th edition; 2007; Plenum.

Reference books:

1. Ingold C.K.; *Structure and mechanism in organic chemistry*; 2nd edition; Cornell University press.
2. Norman R.O.C. and Coxon J. M.; *Principle of Organic Synthesis*; 3rd edition; 1993; Blackie academic professional.
3. Warren S.; *Designing organic synthesis*; 2nd edition; 2008; Wiley; UK.
4. Nasipuri D.; *Stereochemistry of organic compounds*; 5th edition; 2014; New age international
5. Kalsi P.S.; *Stereochemistry of organic compounds*; 2007; New age international.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (1st SEMESTER)

Subject Name: Inorganic Chemistry I	**Level 400**	**Subject Code: CHY014C103**
L-T-P-C – 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objective of **Inorganic Chemistry I** is to provide detailed knowledge on the nature of interactions in compounds and in-depth information about acidic/basic and redox properties of inorganic materials.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Relate** the structure, bonding and properties of coordination and organometallic compounds.	BT1
CO2	**Compare** the interaction between ligands and central atom to solve the problems related to their structure, stability and reactivity	BT2
CO3	**Apply** and **analyse** the knowledge of acidic/basic and redox nature of the inorganic compounds to predict the nature of the reaction	BT 3 &4
CO4	**Evaluate** and **construct** new inorganic compounds to varieties of transition and non-transition elements	BT 5 & 6

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Chemical Bonding** Chemical bonding of simple inorganic covalent compounds-molecular orbital treatments, hybridization, understanding molecular properties from bonding, molecular orbital theory of homo and heteronuclear diatomic, molecular orbitals of polyatomic molecules, molecular shape in terms of molecular orbitals – Walsh diagrams, atomic and ionic radii, bond length, bond strength, van der Waals forces, effect of hydrogen bonding and other chemical forces on melting and boiling points and solubility**.**	**12**
II	**Coordination Chemistry I** Crystal field theory, ligand field theory, splitting of d-orbitals, crystal filed stabilization energies in weak field and strong field, octahedral site preference energy, tetragonal distortion and Jahn-Teller effect, lattice energy, hydration enthalpy and stability of complexes (Irving-Williams order).	**12**
III	**Acid Base and Redox Chemistry** Hard and soft acid-base concept, strength of oxo acids and halo acids, strength of inorganic bases, periodic trends in acidity and basicity of hydrides, oxides, oxyacids of non-transition elements. Standard electrode potentials, pH dependence of electrode potentials, redox stability of metal ions in water, Latimer and Frost diagrams.	**12**
IV	**Non-Transition Metal Chemistry** **S**ynthesis, properties, structure and bonding of nitrogen, phosphorous, sulfur, pseudohalogen, interhalogen and xenon compounds, boranes, carboranes, metallocarboranes, borazines, phosphazenes, sulfur-nitrogen compounds, silicates, silicones.	**12**
Total		**48**

Text Books:

1. *Concise Inorganic Chemistry*; Lee, J.D.; 5th edition; 2013; John Wiley and Sons Ltd.; Indian Edition.
2. *Inorganic Chemistry*; Atkins, P., Overtone, T., Rourke, J., Weller, M. and Armstrong, F.; 6th edition; 2014; Oxford University Press; Indian edition.
3. *Inorganic Chemistry Principles of Structure and Reactivity*; Huheey, J.E, Keiter, E. A., Keiter, R. L and Medhi, O. K.; 4th edition; 2007; Pearson Education.

Reference Books:

1. Wells, A.F.*; Structural Inorganic Chemistry*; 3rd edition; 2012; Oxford Science Publishers.
2. Cotton, F.A., Wilkinson, G., Murillo, A., Bochmann M.; *Advanced Inorganic Chemistry;* 6th edition; 1999; Wiley Interscience; New York.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (1st SEMESTER)

Subject Name: Quantum Chemistry	**Level = 400**	**Subject Code: CHY014C104**
L-T-P: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Quantum Chemistry** are to provide a thorough knowledge of quantum mechanics, solve and apply the approximate methods in real molecules.

Course Outcomes:

After successful completion of the course, the students will be able to

Sl No	Course Outcome	Bloom's Taxonomy Level
CO1	**Define** the postulates and interpret the basic principles of quantum mechanics	BT1 & BT2
CO2	**Apply** quantum mechanical treatment to various models	BT3
CO3	**Analyze** and **Explain** the approximation methods in terms of real molecules	BT4 & BT5
CO4	**Construct** the various orbital theories to **solve** for energy values of different molecules	BT6

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Basic Principles of Quantum Mechanics** Origin of the quantum theory, wave functions of one-particle and many-particles system, probability density, well-behaved functions, normal and orthogonal functions. Operators in quantum mechanics, eigen values and eigen functions, Hermitian operators and their properties, commutation of operators, postulates of quantum mechanics, expectation values of observable properties. Angular momentum of a one-particle system, spin and orbital angular momentum.	**18**
II	**Some Exactly Solvable Problems in Quantum Mechanics** Quantum mechanical treatment of translational motion of a particle, particle in one- and three-dimensional boxes, concept of degeneracy, harmonic oscillator, rotational motion of a particle: particle on a ring, rigid rotator, hydrogen and hydrogen like atoms, graphical presentation of orbitals (s, p and d), radial and angular probability distribution plots.	**18**
III	**Approximate Methods** Need for approximation methods, perturbation and variation methods and their application to Helium atom, symmetric and antisymmetric wave functions, Pauli's exclusion principles, many electron atoms, slater determinants, qualitative treatment of Hartree theory and Hartree-Fock SCF procedure.	**18**
IV	**Chemical Bonding** Born-Oppenheimer approximation, separation of electronic and nuclear motion, hydrogen molecule ion: linear combination of atomic orbital (LCAO)-molecular (MO) theory, valance bond (VB) and MO (LCAO) treatment of hydrogen molecule, comparison of MO and VB treatments and their equivalence limit, Huckel MO theory, FMO.	**18**
	Total	**72**

Text Books:

1. *Quantum Chemistry*; Levine, I.N.; 5th edition, 2000; Prentice Hall of India
2. *Quantum Chemistry;* Prasad, R.K.; 4th edition; 2009; New Age International Publishers Limited

Reference Books:

2. Chandra, A .K.; *Introductory Quantum Chemistry*; 4th edition; 2006;TataMcGrawHill
3. Sen, B.K.; Quantum Chemistry Including Spectroscopy; 4th edition; 2011; Kalyani Publishers, New Delhi
4. McQuarrie, D.A.; *Quantum Chemistry*; 2nd edition; 2011; Viva Books Pvt Ltd
5. Atkins, P.W and S.F. Ronald; *Molecular Quantum Mechanics;* 5th edition; Oxford University Press

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (1st SEMESTER)

Subject Name: Inorganic Chemistry Lab **Subject Code: CHY014C115**

L-T-P-C – 0-0-8-4 **Credit Units: 4** **Scheme of Evaluation: (P)**

Objective: The objective of **Inorganic Chemistry Lab** is to provide hands on training to synthesize inorganic metal complex and analyze quantitatively the acid/base and redox reactions through titrimetric methods

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Relate** knowledge of inorganic chemistry in scientific and technological aspects and synthesise inorganic complexes	BT1
CO2	**Compare** the interaction between ligands and central atom to predict their structure, stability and reactivity	BT2
CO3	**Apply** and **analyze** the knowledge of acidic/basic and redox titrations in quantitative analysis	BT3 & BT4
CO4	**Evaluate** and **construct** new green methods for synthesis of inorganic compounds.	BT5 & BT6

Detailed Syllabus:

List of Experiments:

1) Preparation of following inorganic compounds:
   i. Potassium trioxalatoaluminate (III)trihydrate,$K_3[Al(C_2O_4)_3].3H_2O$
   ii. Hexaamminenickel(II) chloride,$[Ni(NH_3)_6]Cl_2$
   iii. Potassiumtrioxalatoferrate(III) trihydrate,$K_3[Fe(C_2O_4)_3].3H_2O$

2) Preparation of potassium trioxalatochromate(III) trihydrate $K_3[Cr(C_2O_4)_3].3H_2O$ and determination of concentration of chromium and oxalateion.

3) Quantitative analysis of ore/alloy:

i. Determination of the amount of calcium in the limestone sample
ii. Determination of the percentage of copper in Brass sample
iii. Determination of the percentage of iron in steel sample

4) Determination of concentration of components in a mixture

i. Estimation of Fe^{II} and Fe^{III} in a mixture
ii. Estimation of Na_2CO_3 and $NaHCO_3$ in amixture

5) Estimation of alkali content of antacid tablets.

6) Green Chemistry experiments:

i. Recovery and reuse of sulfur dioxide (Obendrauf's Method)
ii. Green synthesis of Tetrabutylammonium tribromide(TBATB)
iii. Preparation of Bis(acetylacetonato)copper(II)

Text Books:

1. *Green Chemistry Experiments: A Monograph;* Sharma R.K., Sidhwani I.T., Choudhuri M.K.; 1st edition (December, 2012); I K International Publishing House.
2. *Vogel's Qualitative Inorganic Analysis;* Svehla G. and Sivasankar B; 7th edition; Pearson.

Reference Books:

1. Barua, S.*; A text Book of Practical Chemistry*; 2th edition; 2016; Kalyani Publishers.
2. Mendham J., Denney R.C., Barnes J.D. and. Thomas M.J.K.; *Vogel's Textbook of Quantitative Chemical Analysis*, 6th edition, 3rd Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (2nd SEMESTER)

Subject Name: Physical Chemistry II	**Level:400**	**Subject Code: CHY014C201**
L-T-P: 4-0-0-4	**CreditUnits:4**	**Scheme of Evaluation: T**

Objective: The objectives of **Physical Chemistry II** are to study the reaction mechanism, theories of reaction rate, kinetic and thermodynamic control of reactions and to understand the properties of polymers and techniques involved in polymerization.

Course Outcomes:

After successful completion of the course, the students will be able to		
S. No.	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Define** rate laws and **understand** the theories that govern the reaction rates.	BT1 & BT2
CO2	**Build** mechanisms of catalysis and **apply** catalytic process in industries.	BT3 & BT4
CO3	**Determine** the degree of polymerization and molecular weights of polymers	BT5
CO4	**Construct** and **compare** various adsorption isotherms	BT5 & BT6

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Reaction Kinetics** Empirical rate law and temperature dependence, steady-state approximation, determination of reaction mechanisms, oscillating reactions: Belousov-Zhabotinski reaction, chain reaction: alkane pyrolysis, branched chain reactions: the hydrogen oxygen reaction, concept of explosion limit. Collision theory, estimation of activation energy and the calculation of potential energy surface, transition state theory (TST) of biomolecular reactions, Eyring equation, kinetic and thermodynamic control of reactions, Lindemann-Hinshelwood theory of unimolecular reactions.	**18**
II	**Catalysis** Types of catalyst, specificity and selectivity, effect of particle size and efficiency of nanoparticles as catalysts. *Homogeneous catalysts*: Mechanism of homogeneous catalysis, acid-base catalysis, enzyme catalyzed reactions, Michaelis-Menten mechanism, effect of pH and temperature, enzyme inhibitor, role of transition metal ions as catalyst with special reference to Cu, Pd, Pt, Co, Ru and Rh, acid-base catalysis. *Heterogeneous catalysts:* Kinetics of heterogeneous catalysis: Langmuir-Hinselwood model, clays, zeolites and their use as catalysts in cracking of petroleum.	**18**

III	**Adsorption and Aggregation** Adsorption of gases on solid surfaces: Langmuir's theory and its limitations, derivation of BET equation: determination of surface area of an adsorbent, adsorption in liquid systems: Gibbs adsorption isotherm. Colloidal system, optical, kinetic and electrical properties of colloids, electrophoresis, electro-osmosis, size determination of colloidal particles, coagulation of colloidal solutions. Surface active agents and their classifications, aggregation /micellization of surfactants, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, thermodynamics of micellization: phase separation and mass action models, microemulsion, reverse micelles.	**18**
IV	**Macromolecules** Polymers and degree of polymerization, classification of polymers, mechanism of polymerization, concept of number average and mass average molecular weight of a polymer, methods of determining molecular weights (osmometry, viscometry, light scattering and sedimentation equilibrium methods), chain configuration of macromolecules: root mean square end to end distance and radius of gyration.	**18**
	Total	**72**

Text Books:

1. *Physical Chemistry;* Atkins, P.W. and Paula, J. de; 10th edition; 2014; Oxford University Press
2. *Principles of Physical Chemistry*; Puri, B.R.; Sharma, L.R.; Pathania, M.S.; 47th edition; 2016; Vishal Publishing Company

Reference Books:

1. Glasstone, S.; *Text book of Physical Chemistry;* 11th edition; 2011; Van Nostrand company.
2. Atkins, P.W. and Paula, J. de; *Elements of Physical Chemistry;* 6thedition, 2012; Oxford University Press.
3. Kapoor, K. L.; *A textbook of Physical chemistry*; 6thedition,; 2011; Macmillan, India Ltd.
4. Levine, I.; *Physical Chemistry;* 6th edition; 2008; McGraw–Hill Science
5. Billmeyer, F.W.; *Text Book of Polymer Science*; 2rd edition; 1971, John.Wiley, London
6. Gowariker, V.R.; Viswanathan, N.V.; Sreedhar, T.; *Polymer Science;* 1st edition; 1986; Wiley Eastern, New Delhi
7. Mishra, G.S.; *Introductory Polymer Chemistry*; 5th edition; 2007; New Age International Gates, B.C.; *Catalytic Chemistry*; 1st edition; 1992; John Wiley & Sons, New York

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (2nd SEMESTER)		
Subject Name: Organic Chemistry II	**Level: 400**	**Subject Code: CHY014C202**
L-T-P-C – 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: (T)**

Objective: To provide the synthetic methodology of organic compounds. To cover the reagents used in organic synthesis. To throw some lights on rearrangement reactions. To discuss about Organometallic reactions.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Understand** the chemistry of reagents and name reactions and their synthetic applications.	BT1
CO2	**Explain** the mechanisms of various rearrangement reactions	BT2
CO3	**Apply** the concept of reagents, ylides and organometallic compounds for the conversion of one functional group into other functional group in one or more number of steps.	BT3
CO4	**Analyze** the structures knowledge of commercially important molecules.	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Reagents in organic synthesis** Complex metal hydrides, DIBAL-H, Gilman's reagent, LDA, DCC, 1,3-propane dithiane, Trimethyl-silyl-tin hydride, Tri-n-butyl-tin hydride, Woodwords and Prevost hydroxylation, DDQ, SeO_2, PPC, PDC, Merifield resins, Peterson's synthesis, Baker's yeast, Chromic acid, Potassium dichromate, Jones reagent, Collins reagent, Birch reduction, Periodic acid, Lead tetra acetate, Osmium tetra oxide, Ozonolysis, m-CPBA, Wittig reagent	**12**
II	**Selective Name Reactions** Aldol, Perkin, Stobbe, Dieckmann condensation, Diels-Ader reactions, Robinson annulation, Michael, Mannich, Stork enamine, Sharpless asymmetric epoxidation, Barton, Ene, Hoffman-Loffler-Freytag, Shapiro, Chichibabin, Cannizaro, Bayer-Hilman, Darens, Benzoin condensation, Knoevenegel, Reimer-Tieman reaction, Wolf-Kishner reduction, Clemmenson reduction, Moningo reduction, Meerwein-Pondorf-Verley reduction, Oppenauer oxidation, Dess-Martin oxidation, Swern oxidation.	**12**

III	**Rearrangement reactions** Wagner-Meerwein, Pinacol-pinacolone, Wolff, Arndt-Eistert synthesis, Hofmann, Curtius, Schmidt, Lossen, Beckmann, Bayer-Villiger, Favorski, Benzillic acid rearrangement, Stevens, Wittig, Claisen, Cope.	**12**
IV	**Ylides and organometallic chemistry:** Methods of generation, properties and reactions of organo magnesium, lithium, cadmium, zinc, copper, boron. Grignard reagent and its application, Reformatsky reaction and its application. Phosphorous and sulfur ylides: methods of generation, properties and reactions.	**12**
Total		**48**

Text books:

1. *Advanced organic chemistry: Reactions, mechanism and structure;* March Jerry; 7th edition; John Wiley.
2. *Advanced organic chemistry*; Carey F. A. and Sundberg R. J.; 5th edition; Plenum.
3. *Principle of Organic Synthesis*; Norman R.O.C. and Coxon J. M.; 3rd edition; Blackie academic professional.
4. *A guide book to mechanism in organic chemistry*; Sykes Peter; 6th edition; 2013, Longman.

Reference books:

1. Carruthers W., *Some modern methods of organic synthesis*; 4th edition; Cambridge University press.
2. Clayden J., Greeves N. and Warren S., *Organic chemistry*; 2nd edition; Oxford University press.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (2nd SEMESTER)

Subject Name: Inorganic Chemistry II	**Level: 400**	**Subject Code: CHY014C203**
L-T-P-C–4-0-0-4	**Credit Units:4**	**Scheme of Evaluation: (T)**

Objective: The objective of **Inorganic Chemistry-II** is to understand and apply the concepts of Inorganic reaction mechanism, inorganic spectroscopy and organometallic compounds. It will also provide in-depth knowledge related to the concepts of symmetry and structure.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Describe** the mechanism of inorganic compounds	BT1
CO2	**Interpret** general features of the electronic absorption spectra including the charge transfer spectra of the transition metal complexes.	BT2
CO3	**Make use** of the 18-electron rule to predict the stability and chemistry of organometallic and transition metal complexes.	BT3
CO 4	**Analyse** structure and symmetry of inorganic compounds	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Inorganic Reaction Mechanism** Substitution in octahedral and square planar complexes, lability, trans-effect, conjugate base mechanism, racemisation, electron transfer reactions: inner sphere and outer sphere mechanism, Marcus theory, inorganic photochemistry: Photo substitution and photo redox reactions of chromium, cobalt and ruthenium compounds, Adamson's rules.	**10**
II	**Coordination Chemistry II** Interpretation of the general features of the electronic absorption spectra including the charge transfer spectra of the transition metal complexes in aqueous solutions, spin-orbit coupling constant and interelectronic repulsion parameters in complex ion terms-vs-free ion terms, vibronic coupling, intensity stealing, band broadening, spectrochemical series, nephelauxetic series, structural distortion and lowering of symmetry, electronic, steric effect on energy levels, magnetic properties, quenching of orbital moment and spin only formula.	**10**
III	**Organometallics** 18 electron rule, metal carbonyls, nitrosyls, cabonyl hydrides, isolobal analogy, dioxygen and dinitrogen compounds, metal alkyls, carbenes, carbynes, alkenes, alkynes, and allyl complexes, hydrides, metallocenes, metal arene complexes, carbonylate anions, oxidative addition and reductive elimination, insertion and elimination reactions, homogeneous and heterogeneous catalysis, fluxional molecules.	**10**
IV	**Symmetry and Structure** Symmetry elements and operations, equivalent symmetry elements and equivalent atoms, symmetry point groups with examples from inorganic compounds, groups of very high symmetry, molecular dissymmetry and optical activity, systematic procedure for symmetry classification of molecules and illustrative examples, molecular symmetry for compounds having co-ordination numbers 2 to9.	**10**
Total		**40**

Text Books:

1. *Concise Inorganic Chemistry*; Lee, J.D.; 5th edition; 2013; John Wiley and Sons Ltd.; Indian Edition.
2. *Inorganic Chemistry*; Atkins, P., Overtone, T., Rourke, J., Weller, M. and Armstrong, F.; 6th edition; 2014; Oxford University Press; Indian edition.
3. *Inorganic Chemistry Principles of Structure and Reactivity*; Huheey, J.E, Keiter, E. A., Keiter, R. L and Medhi, O. K.; 4th edition; 2007; Pearson Education.

Reference Books:

1. Wells, A.F.*; Structural Inorganic Chemistry*; 3rd edition; 2012; Oxford Science Publishers.
2. Cotton, F.A., Wilkinson, G., Murillo, A., Bochmann M.; *Advanced Inorganic Chemistry;* 6th edition; 1999; Wiley Interscience; New York.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (2nd SEMESTER)

Subject Name: Analytical Chemistry	**Level: 400**	**Subject Code: CHY014C204**
L-T-P-C-4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: (T)**

Objective: The objective of **Analytical Chemistry** is to provide a thorough background of principles which are important to chemical analysis and to develop the skills in the proper handling of apparatus and recording of data.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Relate** the importance of chemical analysis with instrumental techniques	BT 1
CO2	**Explain** the concept of purification, separation and identification of the analytes.	BT 2
CO3	**Apply and predict** the nature of the various samples through optical and electrothermal analysis	BT3 & BT6
CO4	**Analyze and measure** the accuracy and errors in experimental data.	BT4 & BT5

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Treatment of Analytical Data** Definition and brief idea of the following terms: Significant figures, accuracy and precision, mean, median, variance, confidence limits, deviation, relative mean deviation, standard deviation. Types of errors in chemical analysis: Determinate and indeterminate error, absolute errors, relative errors, constant and proportional errors, minimization of determinates errors.	**12**
II	**Chromatography and Thermal Methods of Gravimetry** Theory of chromatography, retention time, classification of chromatography, chromatographic techniques – principles, experimental techniques and applications of Gas Chromatography, Liquid Chromatography, Column Chromatography, Thin Layer Chromatography, High-Performance Liquid Chromatography. Thermal Methods: Principle and application of thermal methods of analysis — TGA, DTA and DSC.	**12**
III	**Optical Methods** Fundamental laws of spectrophotometry, nephelometry, turbidometry and fluorimetry. Spectrophotometric titrations. Atomic emission spectrometry: Excitation sources (flame, AC and DC arc), spark, inductively coupled plasma, glue discharge, laser microprobes, flame structure, instrumentation and qualitative and quantitative analysis. Atomic absorption spectrometry: Sample atomization techniques, instrumentation, interferences, background correction, and analytical applications. Theory, instrumentation and applications of: Atomic fluorescence spectrometry, photoelectron spectroscopy, SEM, TEM, AFM.	**12**

IV	**Electro Analytical Methods** Potentiometry: Techniques based on potential measurements, direct potentiometric systems, different types of indicator electrodes, limitations of glass electrode, applications in pH measurements, modern modifications. Polarography: Micro electrode and their specialities, potential and current variations at the micro electrode systems, conventional techniques for concentration determination, limitations of detection at lower concentrations, techniques of improving detection limit-rapid scan, ac, pulse, differential pulse square wave polarographic techniques. Applications of polarography. Amperometry: Biamperometry, amperometric titrations. Coulometry: Primary and secondary coulometry, advantages of coulometric titrations, applications. Principle of chronopotentiometry. Anodic stripping voltammetry: Different types of electrodes and improvements of lower detection limits. Voltammetric sensors.	**12**
	Total	**48**

Text books:

1. *Vogel's Qualitative Inorganic Analysis;* Svehla G. and Sivasankar B.; 7th edition; Pearson.
2. *Fundamental of Analytical Chemistry;* Skoog D.M.*;* Holler and Crouch, West, VIII Edition, 2005, Saunders College Publishing, New York.

Reference Books:

1. MendhamJ., Denney R.C.,Barnes J.D. and. ThomasM.J.K.; *Vogel's Textbook of Quantitative Chemical Analysis*, 6th edition, 3rd Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
2. Day R.A. and A.L., *Quantitative Analysis;* Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
3. *Bioinorganic Chemistry*, 3rd edition; 2006; Wiley.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (2nd SEMESTER)		
Subject Name: Organic Chemistry Lab	**Level:400**	**Subject Code: CHY014C215**
L-T-P-C – 0-0-8-4	**Credit Units: 4**	**Scheme of Evaluation: (P)**

Objective: The objectives of **Organic Chemistry Laboratory** is to provide knowledge of organic chemistry in scientific and technological aspects, to develop curiosity and interest as well as to improve the understanding of the concepts and application of organic chemistry

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Recall** the chemistry behind qualitative analysis of organic compounds	BT1
CO2	**Classify** compounds depending upon the functional groups.	BT2
CO3	**Analyze** and **Apply**the knowledge for synthesis of organic derivative.	BT3 & BT4
CO4	**Measure** and **solve** the compounds with independent thinking.	BT5 & BT6

Detailed Syllabus:

List of Experiments:

1) Qualitative analysis of binary mixtures of organic compounds (min. foursamples)

A. Detection of special elements (N, Cl, S)

B. Solubility and Classification

C. Detection of the functional groups by systematic chemical tests

D. Preparation of derivative of each functional group, purification of crude product by crystallization.

E. Determination of melting point of the given samples and derivatives

2) Chromatography experiments: (anyone)

(a) TLC separation and identification.

(b) Separation techniques of organic compounds by column chromatography and their spectroscopic identification

3) Experiments on Natural products: (any one)

(a) Determination of saponification equivalent of ester/ Saponification of Vegetable Oil, biodiesel**.**

(b) Extraction of carotenoids/Lycopene from a natural source.

4) Synthesis of organic compounds common reagents:

Two steps synthesis- (any one)

(a) Benzoin – Benzil – Benzilic acid) : Base catalysed, rearrangement.

Three steps synthesis- (any one)

(a) Oxidation reaction (b) Reduction reaction (c) Nucleophilic substitution; (d) Cycloaddition reaction; (e) Condensation reaction; (f) Aromatic electrophilic substitution; (g) Preparation of dyes, (h) Heterocyclic synthesis, etc. (e.g., Synthesis of antibacterial compound such as Sulphanilamide, synthesis of p-Amino Benzoic Acid) Preparation of p-acetotoluidine to toluidine

5. Quantitative analysis: (any two)

(a) Determination of equivalent mass of an acid by direct titration method

(b) Estimation of alcohol content in a sample using UV-visible spectrometer

(c) Estimation of sugars using titrimetric (redox) methods.

(d) Glucose and sucrose in a mixture.

6) Green experiments: (any one)

(i) Microwave assisted synthesis of some organic compounds
(ii) Coenzyme catalysed benzoin condensation (thiamine hydrochloride catalysed synthesis of benzoin)
(iii) Nitration of phenol using calcium nitrate tetrahydrate, acetic acid and salicylic acid
(iv) Acetylation of primary amine (Preparation of acetanilide) using aniline, acetic acid and zinc dust.

Text books:

1. V*ogel's Textbook of Practical Organic Chemistry*, Vogel A.I., Aurther I., 5th Edition, 2005, Pearson.
2. *Advanced Practical Organic Chemistry*, Agarwal O. P., 2nd Edition, 2014, Goel Publishing.
3. *Green Chemistry Experiments: A Monograph;* Sharma R.K., Sidhwani I.T., Choudhuri M.K.; 1stedition (December, 2012); I K International Publishing House.

SYLLABUS (3rd SEMESTER)

Subject Name: Spectroscopy-I	**Level: 500**	**Subject Code: CHY014C301**
L-T-P-C-4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: (T)**

Objective: The objectives of **Spectroscopy-I** is to provide the knowledge, techniques and principles of spectroscopy and to develop the ability to solve problems.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Understand** the chemistry of molecular spectroscopy	BT1
CO2	**Demonstrate** the structural characteristics of various types of compounds.	BT2
CO3	**Analyze** and **Apply** the knowledge of spectroscopy to practical apllications.	BT3 & BT4
CO4	**Measure** and **solve** the synthesized organic compounds.	BT5 & BT6

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Basic theory of spectroscopy** Electromagnetic spectrum, interaction of electromagnetic radiation with molecular systems. Spectroscopic transition- absorption, emission, reflection, polarization and scattering processes. Natural line width and broadening- intensity of spectral transitions, selection rules; sampling techniques in different branches of spectroscopy. Electronic transitions, the Frank-Condon principle, ground and first excites states of diatomic molecules, selection rules on the basis of the symmetry properties of the electronic states; vibronic transitions.	**12**
II	**Basic theory of UV-Visible and IR spectroscopy with its application** UV-Visible spectroscopy: Basic principle, process of electronic excitation n-p and p-p transitions, transition probability, solvent effect, factors affecting position and intensity of absorption bands, spectra of dienes, polyenes and unsaturated ketones, calculation of λ_{max}, Woodward –Fieser rules. IR Spectroscopy: Stretching vibrations, Hooke's Law, stretching and bending vibrations. Application of IR spectroscopy: Identity of samples, effects of substitution, conjugation, bond angle, and hydrogen bonding on vibrational frequencies. Detection of inter-and intra-molecular hydrogen bonding.	**12**

III	**Basic theory of ^{1}H and ^{13}C NMR spectroscopy and its application** Nuclear Magnetic Spectroscopy: Basic instrumentation, nuclear spin, nuclear resonance, chemical shift and its measurements, shielding and deshielding, spin-spin interaction, coupling constant, Karplus equation. Simplification of spectra by use of Lanthanide shift-reagents and high magnetic fields. Deuterium exchange technique in the determination of labile hydrogen, spin decoupling, and Nuclear Overhauser effect (NOE). Two-dimensional NMR spectroscopy: COSY, NOESY, DEPT. ^{13}C NMR spectra: Basic theory of ^{13}C NMR spectroscopy. Application of ^{1}H and ^{13}C NMR spectroscopy in the structure elucidation of simple molecules.	**12**
IV	**Basic theory of Mass spectroscopy and its application** Mass Spectroscopy: Basic instrumentation, molecular ion peak, ion production-EI, CI, MALDI techniques. Mass spectral fragmentation of typical organic compounds, common functional groups, McLafferty rearrangement. Application of Mass spectroscopy, examples of mass spectral Fragmentation of organic compounds with respect to their structure determination.	**12**
	Total	**48**

Textbooks:

1. *Organic spectroscopy*; Kemp W.; 3rd edition; 1993; ELBS with Mcmillan.

Reference books:

1. Dyer J. R.; *Application of spectroscopy in organic compounds*; 1994; Prentice Hall; New Delhi.
2. Silverstein Robert M., Webster Francis X., Kiemle David J.; *Spectrometric identification of organic compounds*; 8th edition; 2017; Wiley

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

Subject Name: Biochemistry and Bioinorganic Chemistry	Level: 500	Subject Code: CHY014C302
L-T-P-C-4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)

Objective: The objectives of **Biochemistry and Bioinorganic Chemistry** is to provide the knowledge of molecular structure and interactions present in various biomolecules and bioinorganic compounds that help in understanding functioning and organizing of living organisms.

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Relate** importance of various Essential elements and metals in biological system.	BT1
CO2	**Explain** the structure and biological functions of metalloenzymes.	BT2
CO3	**Apply** the knowledge of effect of Biology-Chemistry interaction on living organism	BT3
CO4	**Analyze** the role of iron in biological system and various chemical reactions happening in biological systems.	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Essential elements and metals in biological system** Essential and trace elements in the biological systems, metals in life, basic reactions in the biological systems and the roles of metal ions in biological processes. Ion transport (active) across biological membrane and its significance, mechanism of Na+/K+ -ion pump. Transport and storage of dioxygen: active site structures and bio functions of O_2-uptake proteins: hemoglobin, myoglobin, hemocyanin and hemerythrin, model synthetic dioxygen complexes. Electron transfer in biology (respiratory electron transport chain): active site structures and functions of cytochromes, cytochrome c. Iron-sulfur proteins: ferredoxines, rubredoxin, cytochrome c oxidase and model systems.	**12**

II	**Metalloenzymes** Copper enzymes, superoxide dismutase, cytochrome oxidase and ceruloplasmin; Coenzymes; molybdenum enzyme: xanthine oxidase; Nitrogenase and nitrogen fixation, zinc enzymes: carbonic anhydrase, carboxypeptidase and interchange ability of zinc and cobalt in enzymes; Vitamin B12 and B12 coenzymes.	**12**
	Chemistry of carbohydrates, proteins and nucleic acids Chemistry of carbohydrates: Types of naturally occurring sugars: Deoxy sugar, amino sugar, branched chain sugar. Killiani-Fischer synthesis, Ruff's degradation, osazone formation, mutarotation.	
III	Metabolism of glucose. Bioenergetics: The ATP cycle. Proteins: Classification, Amino acid, property, peptide, general method of peptide synthesis, primary, secondary, tertiary and quaternary structure of protein. Determination of primary structure. Nucleic Acids: DNA and RNA. Type of RNA and their function, Property of DNA in solution. Watson-Crick Model of DNA structure, replication, transcription and translation.	**12**
IV	**Biochemistry of Iron** Structure and optical spectra; haeme proteins: magnetic susceptibility, epr and electronic spectra; haemoglobin and myoglobin: molecular structures, thermodynamics and kinetics of oxygenation, electronic and spatial structures, synthetic oxygen carriers, model systems; iron enzymes, peroxidase, catalase and cytochrome P-450; iron storage, transport, biomineralization and siderophores, ferritin and transferrins.	**12**
Total		**48**

Textbooks:

1. *Principles of biochemistry*; Lehninger A. L.; 6th edition; 2012; W. H. Freeman and company.
2. *Outlines of biochemistry*; Conn and Stumph; 5th edition; 1987; Wiley and sons, New York.
3. *Organic chemistry*; Solomon T. W. Graham; 12th edition; 2015;Wiley.
4. *Principles of Bioorganic Chemistry*, Lippard S.J.; Berg J.M,; 2nd edition, 2005; Panima Publ. Corpn.

Reference books:

1. Palmer Trevor; *Understanding Enzymes*; 4th edition; 1995; Prentice Hall;UK.
2. Williams R. J. P. and Salvia F. R. De; *Biological chemistry of elements*; 2nd edition; 2001; Oxford University Press.

3. Kraatz H. & Metzler-Nolte N; *Concepts and Models in Bioinorganic Chemistry*, 3rd edition; 2006;Wiley.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (3rd SEMESTER)

Subject Name: Environmental & Green Chemistry	**Level:500**	**Subject Code: CHY014C303**
L-T-P-C-4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: (T)**

Objective: The objectives of **Environmental & Green Chemistry are to provide** the knowledge of major pollutants and different ways of controlling air, water, and soil pollution. The students will also get to know about the principles and methodologies of green chemistry

Course Outcomes:

After successful completion of the course, students will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Define** the major air pollutants and their mitigation methods	BT1
CO2	**Demonstrate** different water pollution and purification methods	BT2
CO3	**Apply** and **analyse** the knowledge of soil chemistry and solid waste management	BT3 & BT4
CO4	**Evaluate** the principles of green chemistry and **construct** new methodology for green synthesis	BT5 & BT6

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Atmospheric Chemistry** Composition of atmosphere – major regions of atmosphere – Particles Ions and radicals in the atmosphere and their formation (formation of particulate matter, Ions and radicals), Air pollution – Major air pollutants – (Oxides of Carbon – Oxides of Nitrogen – Oxides of sulphur- Particulars – Smog and photochemical smog- Metallic pollutants –Radiation – Chemicals – Petroleum – Chlorofluorocarbons) – Effects of Air pollution (Acid rain, Green house effect, Global warming, Depletion of Ozone) –Control of air pollution.	**12**
II	**Hydrosphere Chemistry** Distribution of chemical species in water, Gases in water, alkalinity, organic matter in water, criteria and standards of water quality- safe drinking water, Types of water pollutants – (Biological agents, Chemical agents, Physical agents), Toxic metals in water, Waste water treatment processes, Water purification for drinking and industrial purposes, disinfection techniques, demineralization and reverse osmosis.	
III	**Soil Chemistry** Composition of soil, types of soil, Chemical properties – cation exchange capacity, p^H, macro and micronutrients, Wastes from mining and metal production, Hazardous wastes and their disposal, Biodegradation of waste-anaerobic and aerobic treatment, Incineration, Pesticides and their role in the environment.	**12**
IV	**Green Chemistry** Principles of green chemistry, principles of green organic synthesis, green alternatives of organic synthesis-coenzyme catalysed reactions, green alternatives of molecular rearrangements, electrophilic aromatic substitution reactions, oxidation-reduction reactions, clay catalysed synthesis, condensation reactions, Green photochemical reactions, Green Solvents, Introduction to microwave assisted reactions.	**12**
	Total	**48**

Text books:

1. *Air Pollution: its Origin and Control*; K. Wark, C. F. Warner & W. T. Davis, 3rd edition, 1997,Pearson
2. *Environmental Pollution*, A.K. De, 6th edition, 2006, New Age International, New Delhi.
3. *Environmental Chemistry*, B.K. Sharma & H. Kaur, 2nd edition, 2003, Goel Publishing house, Meerut

Reference books

1. Rao C.S., *Environmental Pollution Control Engineering*, 2nd edition, 2006, New Age International
2. Sanghi R. and Srivastava M. M., *Green Chemistry: Environment Friendly alternatives*, 2nd edition, 2008, Narosa Publishing House, New Delhi, India.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (3rd SEMESTER)

Subject Name: Physical Chemistry Lab	**Level: 400**	**Subject Code: CHY014C314**
L-T-P-C – 0-0-8-4	**Credit Units: 4**	**Scheme of Evaluation: (P)**

Objectives: The objective of Physical Chemistry Laboratory is to provide the knowledge of designing particular experiment in both theoretical and experimental aspects, to develop curiosity and interest as well as to improve the understanding of the concepts in analyzing various physical phenomenon in chemical processes.

Course Outcomes

After successful completion of the course, student will be able to		
Sl. No.	**Course Outcome**	**Bloom's Taxonomy Level**
1	Be able to handle different instruments important in physical and material sciences.	BT 1
2	Be able to get detailed concepts of kinetics of different reactions, autocatalytic reaction and volumetric chemical analysis by doing iodometric titration and able to understand the applications of conductivity, pH-metry and spectrophotometry.	BT 2
3	Apply previous knowledge in analyzing the experimental data to get conclusions.	BT3 & BT4
4	Design the experiment, collect the data and solve the problem with independent thinking.	BT5 & BT6

Detailed Syllabus:

Note: Students shall complete 14 experiments of 7 instrumental and 7 non-instrumental. In the semester end examination, students shall perform 2 experiments.

Unit 1: Chemical kinetics

1) Determine the temperature coefficient and energy of activation of acid hydrolysis of methyl acetate, using least-square calculation.

2) Study the kinetics of the reaction between iodine and acetone in acidic medium by half-life period method and determine the order with respect to iodine and acetone.

3) Study the saponification of ethyl acetate by sodium hydroxide and determine the order of the reaction and energy of activation.

4) Study the autocatalytic reaction between oxalic acid and $KMnO_4$ and determine the order of the reaction.

5) Determine the inversion of sucrose in presence of two acids polarimetrically using Guggenheim plots and hence determine the relative strengths of the acids.

Unit 2: Conductometry

1) Determine the equivalent conductivity of acetic acid at infinite dilution by Kohlrausch's method and hence find out the degree of dissociation of the acid.

2) Find out the relative strength of acetic acid and monochloroacetic acid by conductance measurement.

2) Determine the strength of the components of the following mixtures by conductometric titration.

(a) Hydrochloric acid and acetic acid.
(b) Sulphuric acid and copper sulfate.

Unit 3: *pH*-metry and potentiometry

1) Determine the dissociation constant of acetic acid/ oxalic acid using Hendersen's equation.
2) Find the amount of the components of the following mixtures using pH – metric titration.
a) Hydrochloric acid + acetic acid
b) Hydrochloric acid + oxalic acid

Unit 4: Spectrophotometry

1) Verify Beer's law and determine the concentration of solutions like $KMnO_4$ / $K_2Cr_2O_7$/$CuSO_4$

2) Determine the composition of iron-thiocyanate complex spectrophotometrically by Job's method of continuous variation.

Unit 5: Miscellaneous experiments

1) Determine the molar mass of a polymer by viscometry method.
2) Perform theoretical calculations using a computer on potential energy diagram of hydrogen molecule ion.
3) Determine the coefficient of viscosity of a liquid by Ostwald's viscometer.
4) Determine the surface tension of a liquid by Stalagmometer.

Text Book:

1. *Advanced Practical Physical Chemistry*; Yadav, J.B.; 28th edition; 2009; Goel Publishing House

Reference Books:

1. Gurtu, J.N., Gurtu, A.; *Advanced Physical Chemistry Experiments*, 6th edition, 2014, Pragati Prakashan
2. Halpern, M.; *Experimental Physical Chemistry*, 2nd edition, 1988, Prentice Hall, Upper Saddle River, NJ 07458

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (4th SEMESTER)

Subject Name: Spectroscopy-II	**Level: 500**	**Subject Code: CHY014C401**
L-T-P-C – 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objectives: The objectives of **Spectroscopy-II** are

- To provide a thorough background on those that are particularly important to analytical chemistry
- To provide knowledge, techniques, and principles of spectroscopy and to develop the ability to apply skills in the proper handling of apparatus
- To develop problem-solving skills

Course Outcomes:

After successful completion of the course, students will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Define** and get a detailed idea of rotational, vibrational, and Raman spectroscopy, as well as their molecular geometry and selection rules.	BT1
CO2	**Explain** the origin of chirality, spectroscopic techniques for macromolecules, and their applications	BT2
CO3	**Apply** the concept of Mössbauer spectroscopy and ESR spectroscopy, and their applications	BT3
CO4	**To get information** about NMR and Electronic spectroscopy in inorganic chemistry	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Rotational and Vibrational spectroscopy** Rotational spectroscopy: Classification of molecules based on their moment of inertia, rotational energy levels, molecular geometry determination, stark effect, molecular dipole moment. Rotational spectroscopy of symmetric and asymmetric top molecules. Vibrational spectroscopy: Harmonic and anharmonic oscillators. Morse potential, mechanical and electrical anharmonicity, selection rules. The determination of anharmoncity constant and equilibrium vibrational frequency from fundamental and overtones. Vibrational selection rules using symmetry, polarization of transitions. Normal modes analysis using group theory. Raman spectroscopy- polarizability tensor, Stokes and anti-Stokes lines, instrumentation and applications in chemical and biological systems.	**12**
II	**Principles behind CD/ORD spectroscopy and application** *CD/ORD:* symmetry origin of optical activity of molecules. Phenomenon of Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD): principle, methodology and applications, molecular dissymmetry and chirooptical properties, Cotton effect, Faraday effect in magnetic circular dichroism. Application of CD/ORD spectroscopy for the study of metal-ligand equilibria	**12**
III	**Theory of Mössbauer and Electron Spin Resonance (ESR) spectroscopy with its application** Mössbauer spectroscopy: Gamma ray emission and absorption by nuclei, Mössbauer effect, conditions, nuclear recoil, Doppler effect, instrumentation, chemical shift, quadruple effect, effect of magnetic field, effect of simultaneous magnetic and electric fields. Electron Spin Resonance (ESR) spectroscopy: Introduction, behavior of a free electron in an external magnetic field, basic principle, hyperfine coupling in isotropic system. Factors affecting magnitude of g-values. Line width, double resonance. Application of Mössbauer spectroscopy to the study of high-spin and low-spin iron compounds and in coordination complexes. Application of ESR spectroscopy in transition metal complexes having one unpaired electron including biological systems and to inorganic free radicals.	**12**

IV	**NMR and Electronic spectroscopy in inorganic chemistry** Fluorescence and phosphorescence spectroscopy: Jablonski Diagram, origin of fluorescence and phosphorescence processes, quantum yield, fluorescence quenching-static and dynamic. Instrumentation and applications. NMR spectroscopy: Simple application to diamagnetic inorganic compounds; NMR paramagnetic shifts, simple application to paramagnetic compounds; NMR of ^{31}P and ^{19}F in inorganic compounds. Photoelectron spectroscopy: Basic principles and applications of PES (O_2, N_2 and N_3^- only); chemical information from ESCA.	**12**
Total		**48**

Text books:

1. *Fundamentals of molecular spectroscopoy*; Banwell Colin N., McCashEllain M; 4th edition; 2001; Tata Macgraw-Hill.

Reference books:

1. Rao C. N. R. and Ferraro J. R.; *Spectroscopy in Inorganic Chemistry*; Vol. I & II; 1970 and 1971; Wiley; New York.
2. Greenwood N. N. and Gibb T. C.; *Mossbauer spectroscopy*; 1977; Chappman and Hall ltd; London.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (4th SEMESTER)

Subject Name: Chemical Kinetics and Catalysis	**Level: 500**	**Subject Code: CHY014C402**
L-T-P-C – 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Chemical Kinetics and Catalysis** are

- To study the details of the kinetics of fast reactions, unimolecular reactions, and reactions in solutions
- To acquire knowledge of photochemical reactions and kinetics of different photochemical and electrochemical reactions.
- To understand the theories of heterogeneous catalysis and the properties of zeolites and clays.

Course Outcomes:

After successful completion of the course, students will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	Be able to understand the kinetics of unimolecular reactions.	BT 1
CO2	Be able to understand different techniques used to study fast reactions.	BT 2
CO3	Be able to understand the properties of zeolites and clays	BT 3
CO4	Be able to acquire knowledge of different photochemical reactions.	BT 4
CO5	Know the theories of heterogenous catalysis and kinetics of reactions in solutions	BT 5

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Chemical Kinetics** *Study of fast reactions*: Stopped flow technique, temperature and pressure jump methods. NMR studies in fast reactions, shock tube kinetics, relaxation kinetics. relaxation time in single step fast reactions, determination of relaxation time. *Theories of unimolecular reactions:* Limitations of Hinshelwood's treatment, RRK theory, Slater's treatment, RRKM theory. *Kinetics of reactions in solution:* Diffusion controlled, TST of reactions in solution, Bronsted and Bjerrum equation, effect of ionic strength, kinetic salt effect. Kinetics of electrode reactions: Butler-Volmer equation, Tafel Plots.	**10**

II	**Photochemical reactions** *Photochemical reactions*: Photophysical kinetics- state energy diagrams. Delayed fluorescence- the mechanism and kinetics of fluorescence quenching – Stern-Volmer equation. *Chemical kinetics in the elucidation of reaction mechanism*: Reaction in compounds containing carbonyl groups: photo reduction and related reaction, photocycloaddition reactions, transition metal complexes.	**10**
III	**Zeolites and Clays** Zeolites (natural and systhetic)- shape selectivity properties- solid acids, acidity of zeolites and clays. Mesoporous materials, poorlycrystallinesilicatesandaluminosilicates-MCM-41type materials. Applications of zeolites and clays as heterogeneous catalysts in cracking, reforming, and olefin reactions. Zeolites as catalyst supports. *Surface Characterization Techniques:* Ultra-high vacuum for surface studies, Auger electron spectroscopy, Photoelectron spectroscopy, Scanning probe microscopy,.	**10**
IV	**Kinetics of Heterogeneous Catalysis** Surface area determination from adsorption isotherms and point-B methods, porosity determination by volumetric and gravimetric methods. Chemisorption on metals, semi-conducting oxides, and insulator oxides. Kinetics of heterogeneous catalysis, effect of temperature on rates of catalyzed reactions, Langmuir–Hinshelwood and Eley–Rideal mechanisms, mass transport limitation of catalyzed reactions. Surface dependence of reaction rates, volcano principles	**10**
Total		**40**

Text Books:

1. *Chemical Kinetics*; Laidler, K.J.; 3rd Edition; 2012; Pearson
2. *Fundamental of Photochemistry*; Mukherjee-Rohatgi, K.K.; 3rd edition, 2014, New age international (P)Ltd
3. *Electrochemical Methods: Fundamental and Applications*; J.B. Allen and Faulkner, L.R.; 2nd edition, 2000, Wiley
4. *Heterogeneous Catalysis: Principles & Applications*, Bond, G.C.; 2nd edition, 1987, Oxford University Press
5. *Physical Chemistry of Surfaces;* Adamson, A.W. and Gast, A.P.; 6th edition; 1997; John Wiley and Sons, Canada

Reference Books:

1. Atkins P. W. and Paula J. de; *Physical Chemistry;* 10th edition; 2014; Oxford University Press
2. Levine, I.; *Physical Chemistry*; 6th edition; 2011; Tata McGraw Hill.
3. Puri, B.R.; Sharma, L.R.; Pathania, M.S.; *Principles of Physical Chemistry*; 47th edition; 2016; Vishal Publishing Company
4. J.O. Bockris, A. K. N. Reddy; *Modern Electrochemistry Part 1, 2A and 2B*; 2nd Edition, Springer

5. Chakrabarty, D.K. and Viswanathan, B.; *Heterogeneous Catalysis*; 1st edition; 2011; New Age International (P)Limited
6. Thomas, M.; Thomas, W.J.; *Introduction to principles of heterogeneous catalysis*; 1st edition, 1967; Academic Press, New York
7. Somorjai, G.A.; *Introduction to surface chemistry and catalysis*, 2nd edition; 2010; Wiley-Blackwell,

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (4th SEMESTER)

Subject: Heterocyclic Compounds & Medicinal Chemistry	**Level:500**	**Subject Code: CHY014C403**
L-T-P-C – 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Heterocyclic compounds & Medicinal Chemistry** are

- To help students in the development of curiosity and interest in Medicinal Chemistry
- To help students to understand the structure and reactions of biological molecules
- To provide the students the fundamental concepts required to rationalise and predict the structure of an unknown drug

Course Outcomes:

After successful completion of the course, student will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Understand** the classification, nomenclature, and chemical properties of heterocyclic compounds.	BT1
CO2	**Explain** the methods of synthesis and chemical reactivity of heterocycles.	BT2
CO3	**Apply** the knowledge of medicinal chemistry develop curiosity and interest in Medicinal Chemistry.	BT3
CO4	**Analyze** the synthetic pathways for important therapeutic agents.	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Quinoline and Isoquinoline:** Synthesis of quinolines from anilines, from *ortho*-aminoaryl ketones or aldehydes, synthesis of isoquinolines from 2-arylethamines, from aryl-aldehydes and an aminoacetaldehyde acetal, from ortho-alkynyl aryl-aldehydes or corresponding imines, electrophilic substitution reaction of Quinoline and Isoquinoline. **Indole:** Synthesis of indoles from arylhydrazones, from *ortho*-nitrotoluenes, from *ortho*-aminoaryl alkynes, from *ortho*-alkylaryl isocyanides, from *ortho*-acyl anilides, electrophilic substitution reaction of Indole.	**12**
II	**Basic Chemistry of Alkaloids, Terpenoids and Steroids** Source, structural types of alkaloids, classification, structure elucidation, reactions and synthesis of Nicotine and Papaverine. Reactions and synthesis of Quinine and Morphine. Isoprene rule, general introduction to sesqui-, di- and tri- terpenoids, structure elucidation and synthesis of representative examples of acylic, monocylic and bicyclic monoterpens. Reaction and synthesis of Steroids: Cholesterol, Bile acid, Testosterone, Estrone, Progesterone. Structure and synthesis of Prostaglandins: PGE_2, $PGF_{2\alpha}$.	**12**
III	**Drug Discovery and Design** Design and development of a drug: Choosing a disease, choosing a drug target, target specificity and selectivity, multi-target drugs. Identifying a bio-assay: Choice of bioassay, *in vitro* and *in vivo* tests, high through put screening. Finding a lead compound: Screening of natural products, synthetic compound library and existing drugs, combinatorial and parallel synthesis, computer-aided design of lead compounds, serendipity and the prepared mind; isolation and purification. Optimizing target interactions: Structure-activity relationship-binding role of different organic functional groups, identification of a pharmacophore. Different strategies in drug design: Variation of substituents, extension of the structure, chain extension/contraction, ring expansion/ contraction, isosteres and bioisosteres, simplification of the structure, rigidification of the structure, conformational blockers. Prodrugs: Different roles of prodrugs.	**12**

IV	**Study of Antibacterial Agents and Anti-cancer Agents** History of Antibacterial agents, mechanism of action. Sulphonamides (Antimetabolite): History, mechanism of action, applications. Penicillin: History, structure and properties of benzylpenicillin, mechanism of action of penicillin, resistance to penicillin, methods of synthesizing penicillin analogues. Anticancer agents: An introduction, causes of cancer, genetic faults leading to cancer-protooncogenes and oncogenes, abnormal signaling pathways, insensitivity to growth-inhibitory signals, abnormalities in cell cycle regulation, telomeres, angiogenesis, tissue invasion, and metastasis. Treatment of cancer: Drugs acting directly on nucleic acids- intercalating agents, non-intercalating agents which inhibit the action of topoisomerase enzymes on DNA, alkylating and metalating agents (Nitrogen mustards, Nitrosoureas, Busulfan, Cisplatin, Dacarbazine and Procarbazine, Mitomycin).	**12**
	Total	**48**

Text Books:

1. *An Introduction to Medicinal Chemistry*; Patric G. L.; 6th edition; 2017; Oxford University Press.
2. *Fundamental of Medicinal Chemistry;* Thomas G.; 2nd edition, 2007;Wiley.
3. Heterocyclic Chemistry; Joule J. A., Mills K.; 5th Edition; Jun 2010;Wiley-Blackwell.
4. Principles of Modern Heterocyclic Chemistry; Paquette L. A.; Jan 2010; University of Minnesota.

Reference Books:

1. King F. D.; *Medicinal Chemistry: Principles and Practice*; 2nd edition; Royal Society of Chemistry
2. Clayden J., Greeves N. and Warren S., *Organic chemistry*; 2nd edition; Oxford University press.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**

SYLLABUS (4th SEMESTER)

Subject: Organometallic Chemistry and Catalysis Level: 500 Subject Code: CHY014C404

L-T-P-C – 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)

The objective of **Organometallic Chemistry** is to provide detailed understanding of the main group organometallic compounds. To cover the idea of application of organometallic compounds to organic synthesis and catalysis.

Course Outcomes:

After successful completion of the course, the students will be able to		
Sl No	**Course Outcome**	**Bloom's Taxonomy Level**
CO1	**Define** and get the detailed idea synthesis, structure and reactivity of main group organometallic compounds	BT1
CO2	**Explain** the problems related to their structure and bonding of the various organometallic compounds and predict its stability.	BT2
CO3	**Apply** the idea of organometallic chemistry to understand th syntheses and reactions of cyclopentadienyl and arene meta analogues	BT3
CO4	**Analyse** the catalytic mechanism of different industrially important organic synthesis.	BT4

Detailed Syllabus:

Modules	Topics & Course content	Periods
I	**Main Group Organometallics** Synthesis and reactions of organolithium compounds; Synthesis and reactions of organomagnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls; Thallium(I) organyls (synthesis of TlCp); Organyls of sodium, synthesis of NaCp; Silicon and tin organyls of coordination number 4.	**12**
II	**Transition Metal–Carbon Bond** Transition Metal–Carbon σ-Bond: Brief review of metal alkyl compounds; transition metal carbene and transition metal-carbyne compounds; transition metal vinylidene and transition metal allenylidene compounds. Transition Metal-Carbon π-Bond: Cyclopropenyl cation ($C_3R_3^+$) as a ligand; C_4R_4 as a ligand (R = H, Me, Ph)	**12**
III	**Syntheses and reactions of Cyclopentadienyl and Arene Metal Analogues** Synthesis and reactions of cyclopentadienyl metal carbonyls, cyclopentadienyl metal hydrides, cyclopentadienyl metal halides, arene metal carbonyls, η6-arene-chromium tricarbonyl in organic synthesis.	**12**

IV	**Applications to Organic Synthesis and Homogeneous Catalysis** **In Organic Synthesis**: Hydrozirconation of alkenes and alkynes; Carbonylation of Colman's reagent; η4-diene iron-tricarbonyls in organic synthesis **In Catalysis**: Asymmetric hydrogenation; synthesis of acetic acid and glycol (Monsanto acetic acid process); arylation/vinylation of olefins (Heck reaction); Wacker process (olefin oxidation); Asymmetric epoxidation	**12**
Total		**48**

Text Books:

1. *Organometallics*; *Elschenbroich.C*; 3rd edn.,2006; Wiley-VCH Publication.
2. *Advanced Inorganic Chemistry*; Cotton F. A. & Wilkinson. G.; 5thedn.; 1988, John Wiley

Reference Books:

1. Crabtree, R. H.; *The Organometallic Chemistry of the Transition Metals*; 4th edn.; 2005; John Wiley.
2. Bochmann.M; *Organometallics-I Complexes with Transition Metal- Carbon σ-Bonds*, 3rd edition, 1994; Oxford Chemistry Primers.
3. Bochmann.M; *Organometallics-2 Complexes with Transition Metal– Carbon π-bonds*; 3rd edition, 1994; Oxford Chemistry Primers.

Credit Distribution		
Theory/ Tutorial	**Practicum**	**Experimental Learning**
72	**---**	**48**