IIS (deemed to be UNIVERSITY), Jaipur
Department- Chemistry
Programme- B.Sc. Chemistry
OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	Employ critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology.
PO5	Acquire the ability to engage in independent and self-learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports.
PO7	Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread knowledge, creating awareness

	about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO9	Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.

PROGRAMME SPECIFIC OUTCOMES

UG Syllabus (2020-21)

The Bachelor of Science in Chemistry programs offer students a quantitative experience in chemistry**.** The purpose of the undergraduate chemistry program at the IIS(deemed to be University)is to provide fundamental knowledge of the major fields of chemistry to students covering the general areas of inorganic, organic, and physical chemistry and all other related allied chemistry subjects including many more specialized courses .These undergraduate students are exposed to applied laboratory techniques, critical thinking, independent and team learning, and are provided with research opportunities. The faculty is committed to providing an environment that addresses the individual needs of each student and encourages them to develop their potential*.* After the completion of the programme, students will be able to -

PSO1	Have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. They will have extensive laboratory work and knowledge of Biological Chemistry.
PSO2	Develop critical thinking and analytical reasoning as applied to scientific problems.
PSO3	Develop skill in problem solving where the learner will develop the capability to function as a member of an problem solving team. The learner will be capable to – a. identify the issues. b. list the possible solutions (options) c. evaluate the options d. select a correct option(s)
PSO4	Appreciate the understanding of safe handling of chemicals, toxic hazards, long term health effects from chemicals and environmental issues.
PSO5	Foster the ability to focus different minds on the same problem, mutual support, commitment, accountability, conflict management, trust, focusing on results and increased efficiency in their personality.

PSO6	Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
PSO7	Understand documents with in-depth analyses and logical arguments and can clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH POS)

Course	Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CHY-101	CO1	X	X	X			x	
	CO2		X					
	CO3		X					
	CO4		X					x
	CO5		X	X			x	
	CO6	X	X			x		x
	CO7	X						x
CHY-102	CO8		X					x
	CO9		X					
	CO10		X					
	CO11		X	X		x		
	CO12							x
CHY-103	CO13	X		X		x		
	CO14	X		X				x
	CO15	X		X				x
	CO16	X		X				x
	CO17	X	X	X				x
	CO18	X		X				x
CHY-104	CO19				x			
	CO20		X	X	x			
	CO21	X			x		x	
CHY-201	CO22	X						x
	CO23	X						x
	CO24		X	X				
	CO25	X						
	CO26				x			x
CHY-202	CO27	X						
	CO28	X	X					
	CO29		X	X				x
	CO30	X	x	X				

CHY-203	**CO31**	X	x					x
	CO32	X	x	X		x		
	CO33		x	X		x		
	CO34	X						x
	CO35	X						
CHY-204	**CO36**	X		X	x	x		
	CO37	X	x					X
	CO38	X			x			
	CO39		x	X	x	x	x	
CHY-301	**CO40**	X						X
	CO41		x					X
	CO42		x			x	x	
	CO43		x			x	x	X
CHY-302	**CO44**	X	x	X				
	CO45		x					X
	CO46	X		X				
	CO47	X	x	X				
	CO48		x					X
CHY-303	**CO49**	X	x	X		x	x	X
	CO50		x	X			x	
	CO51	X		X				X
	CO52	X		X				
	CO53	X		X				
	CO54	X	x	X				X
	CO55			X				
CHY-304	**CO56**	X			x			
	CO57		x	X	x			
	CO58	X			x	x	x	
	CO59			X	x	x		
CHY-401	**CO60**	X	x					X
	CO61	X						X
	CO62	X	x			x		
	CO63		x	X		x		X
	CO64	X						X
CHY-402	**CO65**	X						
	CO66	X						
	CO67	X	x	X				
	CO68	X						X
	CO69	X				x		X
	CO70		x	X				X
CHY-403	**CO71**	X		X				X
	CO72	X		X		x		X
	CO73		x	X				
	CO74		x	X				X
	CO75	X		X				X
	CO76	X			x	x		

CHY-404	**CO77**	X			x	x		
	CO78	X			x	x		
	CO79	X			x	x	x	
	CO80	X			x	x	x	X
CHY-501	**CO81**	X						
	CO82		x	X				
	CO83	X		X				
	CO84	X	x	X			x	X
	CO85	X						X
CHY-502	**CO86**	X						X
	CO87	X						
	CO88	X						X
	CO89	X	x	X				
	CO90	X	x	X				
CHY-503	**CO91**	X						
	CO92	X						
	CO93	X					x	X
	CO94	X	x	X				
	CO95	X						X
	CO96	X						
CHY-504	**CO97**	X	x		x			
	CO98	X						X
	CO99	X						
CHY-601	**CO100**	X						
	CO101	X						X
	CO102	X	x	X				
	CO103	X						X
	CO104	X						
CHY-602	**CO105**	X						X
	CO106	X	x	X				
	CO107	X				x		X
	CO108	X	x					
	CO109	X	x					
CHY-603	**CO110**	X						X
	CO111	X						X
	CO112		x	X				
	CO113	X						X
	CO114	X						
CHY-604	**CO115**	X			x	x		
	CO116	X						X
	CO117	X	x	X				
	CO118	X			x			
	CO119	X			x	x		

B.Sc. CHEMISTRY (2020-21)
COURSE OUTCOMES - Semester I

PAPER CODE- CHY 101
Molecular Structure and Bonding
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to -

1. Provide an in-depth knowledge about different types of bonding in main group elements
2. Acquaint the students with the concept of hybridization and geometry of covalent molecules, shapes of atomic and molecular orbitals.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 101	**Molecular Structure and Bonding (Theory)**	**The students will be able to –** **CO1:** calculate the radius ratio of ionic molecules and determine the ionic structures of the type AX and AX2 **CO2:** apply the concept of Born Haber cycle in predicting the lattice energy, ionization energy and stability of the ionic compounds. **CO3:** differentiate the types of defects in solids. **CO4:** describe the various types of hybridization and geometry of molecules. **CO5:** construct molecular orbital diagrams of homo and hetero nuclear diatomic molecules and determine the bond order with the help of M.O. diagram **CO6:** discuss the different theories of metallic bonding and distinguish between types of Van der Waals interaction **CO7:** explain types, properties, theories of H-bonding and its effect on physical properties.	▪ Class lectures Tutorials ▪ Group discussions ▪ Peer teaching and learning	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Problem-solving exercises ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I: The Ionic Bond **7 hrs**

Introduction, size effects, radius ratio rules- Calculation of limiting radius ratio values for coordination number 3,4 ,6 and 8; Close packing; classification of ionic structures, (ionic compounds of the type AX (ZnS, NaCl, CsCl) and AX_2 (CaF_2-Fluorite)), limitations of radius ratio rule; Calculation of lattice energy, factors affecting lattice energy; the Born Haber cycle and its application; solvation energy and solubilities of ionic substances; stoichiometric and non-stoichiometric defects.

Unit II: The Covalent Bond **7 hrs**

The Lewis theory, octet rule, explanations for the failure of octet rule, exceptions to octet rule, valence bond theory (Heitler and London approach) and its limitations; resonance, directional character of covalent bond, various types of hybridization (sp, sp^2, sp^3, sp^3d,sp^3d^2, dsp^2, sp^3d^3) and shapes of molecules; VSEPR theory, isoelectronic principle, examples using VSEPR theory, polarizability of ions, Fajans' rule and consequences of polarization, dipole moment and percentage ionic character in covalent compounds (electronegativity difference and dipole moment method), bond energy and bond length.

Unit III: Molecular Orbital Approach in Covalent Bond **6 hrs**

Introduction, LCAO approach, combination of orbitals (s-s, s-p, p-p, non-bonding combination of orbitals), examples of molecular orbital treatment for homonuclear diatomic molecules– H_2^+, H_2, He_2, B_2, C_2, N_2, Be_2, O_2, O_2^{+1}, O_2^{-1}, O_2^{-2}, F_2, examples of molecular orbital treatment for heteronuclear diatomic molecules - NO, NO^+, CO, CO^+, CO^-, CN, CN^- molecule, comparison of VBT and MOT.

Unit IV: The Metallic Bond **5 hrs**

Multicentered bonding in electron deficient molecule, general properties of metals– conductivity, lusture, malleability, ductility, crystal structures; theories of bonding in metals – Free electron theory, valence bond theory and band theory – Conductors, insulators and semi-conductors, superconductors.

Unit V: Weak Interactions **5 hrs**

Vander Waals forces: Ion-dipole forces, dipole-dipole interactions, induced dipole interactions, instantaneous dipole – induced dipole interactions, repulsive forces.

Hydrogen bond: Types, theories and properties of H-bond, effects of H-bond on physical properties.

BOOKS RECOMMENDED

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; OxfordUniversity Press, New York, 2018.

PAPER CODE- CHY 102
Some Concepts of Organic Chemistry and Hydrocarbons
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to -

1. Make the students understand the core concepts of organic chemistry i.e. resonance, hyperconjugation, inductive effect etc. and theirqualitative and quantitative treatment
2. Provide an in-depth knowledge about alkanes, alkenes & alkynes and their reactions.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 102	**Some Concepts of Organic Chemistry and Hydrocarbons (Theory)**	**The students will be able to –** **CO8:** explain the different nature and behavior of organic compounds based on fundamental concepts **CO9:** identify various organic reaction mechanisms including free radical substitution, electrophilic and nucleophilic addition reactions **CO10:** identify different electronic effects, their role and impact on molecules **CO11:** to solve problems based on the concept of electronic effect **CO12:** illustrate the mechanism of organic reactions on hydrocarbons depending upon the reactants involved.	• Interactive Lectures • Discussions, Tutorials • Quiz • Problem solving	• The oral and written examinations (Scheduled and surprise tests) • Closed-book and open-book tests • Problem-solving exercises • Assignments • Quiz • Semester End Examination

CONTENTS

Unit I: Basics of Organic Reactions and Alkanes **7 hrs**

Pre requisite: Inductive effect, electromeric effect, introduction to hydrocarbons, branched and unbranched alkanes, physical properties, different methods of formation of alkane, conformation of alkanes and cycloalkanes, CFC'S and greenhouse effect.

Chemical Reactions: Types of fission, reactive intermediates, structure and stability of the reaction intermediates(carbocation, carbanion and free radical) energy profile diagram, hyperconjugation, applications of different electronic effects (inductive effect, electromeric effect, and mesomeric effect).
Alkanes: Reactivity of alkanes- bond dissociation energies, halogenation with special reference to generation of free radicals, reactivity and selectivity.

Unit II: Alkenes: Structure and Reactivity **5 hrs**

Pre requisite: Hybridization of carbon, cis-trans isomerism, IUPAC nomenclature, general methods of preparation, physical properties.
Structure and bonding in alkenes, heat of hydrogenation; methods of formation – dehydration of alcohols (formation of carbocation, structure and stability), dehydrohalogenation of alkyl halide, relative stability of alkene isomers by Saytzeff's rule and Hoffmann's rule; Regioselectivity

Unit III: Chemical reaction of alkenes **7hrs**

Mechanism involved in hydrogenation, electrophilic and free radial addition, Markovnikov's rule, hydroboration oxidation, oxymercuration-reduction, oxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$and OsO_4

Unit IV: Dienes **5 hrs**

Structure and stability of conjugative and cumulative dienes, resonance and molecular orbital structure of allene and 1,3-butadiene; methods of preparation, Diels' Alder reaction; addition of hydrogen halides to conjugated dienes – 1,4 v/s 1,2 addition (formation, structure and stability of allylic carbocation and free radicals).

Unit V: Alkynes **6 hrs**

Pre requisite: Nomenclature, structure and bonding, physical properties, hydroboration-oxidation reaction.

Structure and stability; methods of preparation, acidity of alkynes, chemical reactions, mechanism of electrophilic and nucleophilic addition reactions; reduction of alkynes – catalytic hydrogenation, dissolving metal reduction.

Self Study : Industrial applications of alkynes.

BOOKS RECOMMENDED

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York,2008.
- Organic Chemistry; Sixth Edition; G. Marc Loudon, J. Parise; WH Freeman, New York, 2015.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.

PAPER CODE- CHY 103
States of Matter
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to -

1. Learn about mathematical concepts which will be helpful in chemical derivations
2. Enhance the knowledge on principles and bulk property of matter.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

CHY 103	**States of Matter (Theory)**	**The students will be able to –** **CO13:** solve differential and integration problem at various level of derivation in physical chemistry. **CO14:** describe physical properties of each state of matter and law related to these states. **CO15:** explain the behaviour of real and ideal gas. **CO16:** explain structure and application of liquid crystal. **CO17:** describe law of crystallography and apply these laws. **CO18:** summarize different method of preparation and properties of sol, gel and emulsion.	▪ Interactive Lectures ▪ Discussion ▪ Tutorials ▪ Reading assignments ▪ Demonstration ▪ Revision in form of interactive quiz (crossword, zig-saw puzzle, match the pair)	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed-book and open-book tests ▪ Problem-solving exercises ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I : Mathematical Concepts **5 hrs**

Logarithmic relations, differentiation of simple functions like, x^n,e^x, log x, rules of differentiation, maxima and minima, linear graphs and calculation of slopes, partial differentiation,integration of some useful/relevant functions.

Unit II : Gaseous State **9 hrs**

Pre requisite: Gas laws.

Postulates of kinetic theory of gases, deviation from ideal behaviour, van der Waals equation of state.Qualitative discussion of the Maxwell's distribution of molecular velocities,molecular velocities: Root mean square, average and most probable velocities, collision number, collision frequency, mean free path and collision diameter; liquefaction of gases (based on Joule-Thomson effect).

Critical Phenomena: PV isotherms of real gases, continuity of states, isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, law of corresponding states, reduced equation of states.

Unit III : Liquid State **6 hrs**

Qualitative treatment of the structure of the liquid state, intermolecular forces, physical properties, vapour pressure, heat of vaporization, Trouton's rule; surface tension and its measurement by stalagmometer method; viscosity and its measurement by Ostwald's method, effects of temperature, coefficient of viscosity; application of surface tension and viscosity in determination of chemical constitution.

Liquid crystals: Classification, structure of nematic, smectic and cholestricphases, applications of liquid crystals.

Unit IV : Solid State **6 hrs**

An introduction to space lattice and unit cell, laws of crystallography – (i) law of constancy of interfacial angles (ii) law of rationality of indices (iii) law of symmetry, symmetry elements in crystals, X-ray

diffraction by crystals, derivation of Bragg's equation, determination of crystal structure by different methods, determination of crystal structure of NaCl, KCl and CsCl.

Unit V : Colloidal State **4hrs**

Pre requisite: Definition and classification.

Solids in liquids (Sols): Properties- kinetics, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.

Liquid in liquids (Emulsions): Types, preparation and emulsifier.

Liquids in solids (Gels): Classification, preparation and properties, inhibition, general applications of colloids.

BOOKS RECOMMENDED

- A Textbook of Physical Chemistry; Second edition, A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- University General Chemistry; C.N.R. Rao; Laxmi Publications, New Delhi, 2015.
- Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Second Edition, New Age International Pvt. Ltd, New Delhi, 2001.
- The Chemical Maths Book; Second Edition Steiner, E. Oxford University Press, New York, 2011.

PAPER CODE- CHY 104
Laboratory Course
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Acquaint the students with various safety measures including handling of chemicals, safe disposal of chemical wastes etc.
2. Make students understand the concept of separation of mixtures containing metal ions.
3. Make students learn about the determination of percent composition of binary solutions by using viscometer and stalagmometer

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 104	**Laboratory Course (Practical)**	**The students will be able to –**	▪ Class lectures ▪ Discussions	▪ written test ▪ viva voce ▪ Quiz

		CO19: apply the knowledge of lab safety measures during the experimental work. **CO20:** analyze and detect various cations and anions in the presence of each other in a given mixture qualitatively. **CO21:** determine the percentage composition of non interacting systems by viscosity and surface tension method.	▪ Demonstrations	▪ Semester end examination

CONTENTS

Laboratory Safety measures **4hrs**

Handling of hazardous chemicals, incompatible chemicals, flammable solvents, fire hazards in chemical laboratory, control of fire, fire extinguishers, toxicity of chemicals, forms of toxic materials, personal protective equipment, health effects and first aid, MSDS (material safety data sheet), use of compressed gases, waste minimization strategies and chemical waste disposal, procedures for neutralization of strong acids and strong bases.

Inorganic Chemistry **48hrs**

Qualitative Analysis: Semi micro Analysis – (three cations and three anions)
a) cation analysis, separation and identification of ions from groups I-VI.
b) anion analysis. (no interfering radicals and insolubles).

Physical Chemistry **8 hrs**

Surface tension: To determine the percentage composition of a mixture (non-interacting systems) by surface tension method.
Viscosity: To determine the percentage composition of a mixture (non-interacting systems) by viscosity method. To determine the viscosity of alcohol in water at different concentrations.

BOOKS RECOMMENDED

- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Vogel's Qualitative Inorganic Analysis; Seventh Edition; G. Svelha, B. Sivasankar; Pearson Education India,2012.
- Semimicro Qualitative analysis; J.P.Tandon, LalManohar,R.K.Bansal; University of Rajasthan, Jaipur,1979.

COURSE OUTCOMES - Semester II

PAPER CODE - CHY 201
Inorganic Chemistry I
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. make the students recall the general trends in the periodic table of elements.
2. equip students with the knowledge of gradation in properties of main group elements and theoretical concepts of different titrations of volumetric analysis like principle,applications and indicators used etc.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 201	**Inorganic Chemistry I (Theory)**	**The students will be able to –** **CO22:** describe the structures, properties, applications and the chemical reactivity of the s-block elements. **CO23:** explain two-center, three-electron bonding using both valence bond and molecular orbital approaches and Differentiate the different allotropes of the p block elements. **CO24:** interpret and utilize Latimer diagrams for predictions of chemical behaviour, including relative strengths of species as reductants and oxidants. **CO25:** utilize reduction potentials to determine relative strengths of oxidants or reductants. **CO26:** define and explain standardization, indicators, and primary standards and their use and Carry out volumetric analysis and related calculations.	▪ Traditional chalk & board method with interactive lectures ▪ Group discussions ▪ Peer teaching and learning ▪ Question preparation- Subjective type-Long answer &Short answer ▪ Objective type- ▪ Multiple choice questions, ▪ One answer/two answer type questions ▪ Assertion and reasoning	▪ Class test ▪ Semester end examinations ▪ Quiz ▪ Solving problems in tutorials ▪ Assignments ▪ Presentation

CONTENTS

Unit I : s-Block Elements **6 hrs**

General properties and comparative study of alkali and alkaline earth metals, diagonal relationship, anomalousbehaviour of Li and Be, salient features of hydrides and their classification (ionic, covalent and interstitial), solvation and complexation tendencies (crown ethers and cryptands).

Unit II : Periodicity in Properties of p-Block Elements **7 hrs**

Prerequisite: General Properties of main group elements mentioned in semester I

Periodicity in properties of p-block elements with special reference to atomic and ionic radii, ionization energies, electron-affinity, electronegativity, allotropy, inert pair effect, catenation including diagonal relationship.
Some important compounds of p-block elements: Group 13 elements – Boron hydrides (diborane) and borazine; group 14 elements – Carbides and its classification, silicates (classification and structural aspect); group 15 elements – Structural aspects of oxides and oxy acids of N & P;group 16 elements – Structural aspects of oxy acids of S including peroxo acids.

Unit III : Halogens and Noble Gases **6 hrs**

Unique position of Fluorine, basic nature of halogen, interhalogen compounds and polyhalides (only structural study).
Noble gases- Introduction, isolation, physical properties and uses,xenon compounds.

Unit IV : Oxidation and Reduction **6 hrs**

Reduction potentials – Redox half reactions, concept of over potential, diagrammatic presentation of potential data (Latimer, Frost and Pourbaix diagrams),redox stability in water, reactions with water, disproportionation, oxidation by atmospheric oxygen,elements extracted by reduction – Ellingham diagrams.

Unit V : Basic Principles of Volumetric Analysis **5 hrs**

Prerequisite: Basic principles of acid base titrations.

Simple theoretical background of following types of titrations:
Iodometric&iodimetric titrations: Basic principle, application in standardization of iodine by $CuSO_4$-hypo and H_3AsO_3.
Redox titrations : Standard potential, SHE, electrochemical series, emf calculations, internal & external indicators, applications in $K_2Cr_2O_7$ oxidation reaction.
Complexometric titrations: Types of EDTA titrations, masking and de-masking agents, metal ion indicator, application in estimation of total hardness of water.
Precipitation titrations: Basic principle, application inVolhard's method.

BOOKS RECOMMENDED:

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; OxfordUniversity Press, New York, 2018.
- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.

PAPER CODE- CHY 202
Aromaticity and Stereochemistry
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to -

1. Make the students understand the core concepts of organic chemistry, resonance, hyperconjugation, inductive effect etc. and other electronic effects including their qualitative and quantitative treatment.

2. Provide an in-depth knowledge about the organic-chemical reactions with a focus on aromaticity &stereochemistry.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 202	**Aromaticity and Stereochemistry (Theory)**	**The students will be able to –** **CO27:** identify the different aromatic, non-aromatic, homoaromatic & antiaromatic compounds and interpret their properties. **CO28:** learn and identify many organic reaction mechanisms including electrophillic aromatic substitution. **CO29:** predict and describe various types of reactive intermediates, reactivity and factors affecting the reactivity and stability of aromatic substrates. **CO30:** apply the fundamental concepts of stereochemistry on simple molecules.	▪ Class lectures ▪ Tutorials ▪ Group discussions Peer teaching and learning ▪ Question preparation ▪ Subjective type ▪ Long answer ▪ Short answer ▪ Objective type ▪ Multiple choice questions ▪ One answer/two answer type questions ▪ Assertion and reasoning	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed-book and open-book tests ▪ Problem-solving exercises ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I : Aromaticity **5 hrs**

Pre requisite: Nomenclature of benzene derivatives (mono and disubstituted), physical properties

Introduction to aromatic compounds: Benzene, structure and stability, M.O concept, resonance and resonance energy; aromaticity and Hückel's (4n+2) rule, magnetic criteria.

Unit II : Directing Effects of Substituents **6 hrs**

Aromatic electrophilic substitution – general pattern of the mechanism, σ and π complexes, energy profile diagram,activating and deactivating effects of substituents, orientation,o/p ratio, halogenation, nitration, sulphonation and desulphonation, FriedelCrafts alkylation and acylation; side chain halogenation of alkyl benzenes (toluene, ethyl benzene), Birch reduction

Self Study: Hydrogenation of benzene derivatives, industrial use of aromatic hydrocarbons.

Unit III : Principles of Stereochemistry **7 hrs**

Geometrical isomerism: concept of restricted rotation – cis-trans, syn-anti and E,Z system of nomenclature, geometrical isomerism in oximes, amides and alicyclic compounds. Optical isomerism: elements of symmetry, concept of asymmetry and chirality, enantiomers and diastereomers, racemic mixture and meso isomers; molecular chirality – allenes, relative and absolute configuration, nomenclature of optical isomers – D,L nomenclature, sequence rule and the R,S system of nomenclature, resolution of enantiomers; elementary concepts of asymmetric synthesis (concept of diastereomeric induction).Elementary concept of chiral induction through chemical reaction (reaction of bromine to alkane and alkenes)

Self Study: Physical properties of enantiomers and diastereomers, optical activity, polarized light, optical activity of enantiomers.

Unit IV : Cycloalkanes **6 hrs**

Nomenclature, method of preparation, chemical reactions, theory of strainless rings, cyclopropane and its reactivity with halogens.

Unit V : Conformational analysis: Concept of Free Rotation **6 hrs**

Newman, Fischer, Sawhorse and Flying-wedge formula; conformation of ethane, n-butane and cyclohexane **–** axial and equatorial bonds, conformational analysis of monosubstituted and disubstituted cyclohexane (dimethyl cylcohexane), concepts of conformational locking; chair conformation of α and β glucose and their stability.

BOOKS RECOMMENDED:

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York,2008.
- Organic Chemistry; Sixth Edition; G. Marc Loudon, J. Parise; WH Freeman, New York, 2015.
- Stereochemistry: Conformation and Mechanism; Eighth Edition; P.S. Kalsi; New Age International Publishers Pvt Ltd, New Delhi, 2015.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.
- Stereochemistry of Organic compounds; First Edition; Ernest L. Eliel, Samuel H. Wilen; Wiley Interscience,1994.

PAPER CODE- CHY 203
Thermodynamics and Electrochemistry
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to -

1. Make the students learn various laws of thermodynamics and their applications.
2. Acquaint the students with the concept of electrochemistry.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 203	**Thermodynamics and Electrochemistry (Theory)**	**The students will be able to –** **CO31:** discuss and apply the basic concepts of first law of thermodynamics. **CO32:** solve basic problems of thermo chemistry. **CO33:** calculate entropy for various thermodynamic processes. **CO34:** explain the basic concept of electrochemistry. **CO35:** learn fundamental concepts of ionic equilibrium.	▪ Interactive Lectures ▪ Discussions ▪ Tutorials ▪ Problem solving	▪ Presentations by Individual Student/ Group of Three Students ▪ Class Tests at Period Intervals. ▪ Written assignment(s) ▪ Semester End Examination

CONTENTS

Unit I : Thermodynamics: First law **6 hrs**

An overview of thermodynamic terms, intensive and extensive properties, state and path functions and their differentials, thermodynamic processes, concept of heat and work.
First law of thermodynamics: Statement, definition of internal energy and enthalpy, heat capacity, heat capacities at constant volume and pressure and their relationship; Joule- Thomson effect, Joule-Thomson coefficient for an ideal gas & real gase,inversion temperature.

Unit II : Thermodynamics: Applications of First law-Thermochemistry **6 hrs**

Standard state, standard enthalpy of formation,enthalpy of neutralization, heat of reactions at constant pressure and at constant volume,Hess's law of constant heat summation and its applications, bond dissociation energy and its calculation from thermo-chemical data,Kirchhoff's equation.

Unit III : Thermodynamics: Second law and thirdlaw **7 hrs**

Second law of thermodynamics: Need for the law, different statements of the law, Carnot cycle and its efficiency, Carnot theorem, thermodynamic scale of temperature.
Concept of entropy: Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical processes.
Third law of thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data.

Unit IV : Electrochemistry: Electrolytic conduction 6hrs

Electrical transport, conductance in metals and electrolytes, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution.
Applications of conductivity measurements: determination of degree of dissociation, acid dissociation constant, solubility product of a sparingly soluble salt; conductometric titrations.

Unit V : Electrochemistry: Ionic equilibria 5hrs

Arrhenius theory of electrolytic dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations, Debye-Hückel-Onsager's equation for strong electrolytes (elementary treatment only), migration of ions and Kohlrausch'slaw, transport number – definition and determination by Hittorf and moving boundary method.

BOOKS RECOMMENDED:

- A Textbook of Physical Chemistry; A.S. Negi and S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India, 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.
- Physical Chemistry Through Problems; Second Edition; S.K. Dogra and S.Dogra; New Age International Pvt. Ltd, New Delhi, 2001.

PAPER CODE- CHY 204
Laboratory Course
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. Enable the students to acquire knowledge of conductometric titrations and their calculations. Make the students to get an insight on the use of apparatus used in volumetric analysis and correct titrimetric procedure along with standard and non standard solutions.

2. Enable them to perform all sorts of volumetric calculations. Acquaint students with the identification of different functional groups and draw formulas and structures of these groups

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 204	**Laboratory Course (Practical)**	**The students will be able to –** **CO36:** inculcate the skills in the quantitative analysis by doing titrations in the different types of volumetric analysis and learn the principle difference between iodometric and iodimetric titrations **CO37:** impart a thorough knowledge about the chemistry of some selected functional groups and classify organic compounds based on functional groups **CO38:** develop skills required for the qualitative analysis of organic compounds, determination of melting and boiling points **CO39:** interpret conductometric titrations and compose the curves for conductometric titration and determine the specific and equivalent conductance of the given electrolyte at different dilutions	▪ Demonstration ▪ Interactive lectures ▪ Problem solving Tutorials	▪ Class test ▪ Semester end examinations and observation

CONTENTS

Inorganic Chemistry **12 hrs**

Calibration of fractional weights, pipettes and burettes, preparation of standard solutions, dilution – 0.1 M to 0.001 M solutions, buffer solutions.
Quantitative Analysis: Volumetric Analysis **(Any four)**

1. Iodometry titration – Determination of strength of $CuSO_4$ solution using sodium thiosulphate.
2. Redox titrations –
   (a) Determination of strength of ferrous sulphate solution using $K_2Cr_2O_7$
   (b) Estimation of ferrous (Fe^{+2}) and ferric (Fe^{+3})ionby dichromate method.
3. Acid-base titration –
   (a) Determination of acetic acid in commercial vinegar using NaOH.
   (b) Determination of strength of acid from the mixture of strong acid and weak acid (e.g. $H_2SO_4$and H_3PO_4).
   (c) Determination of strength of sodium carbonate and NaOH in the mixture of washing soda and NaOH with HCl using phenolphthalein and methyl red indicator.
4. Complexometric titration – Estimation of hardness of water by EDTA (Temporary and permanent).

Organic Chemistry
Qualitative Analysis **38 hrs**

Detection of elements (Nitrogen, Sulphur and Halogens) and functional groups (phenols, alcohols, carboxylic acid, carbonyl, ester, carbohydrate, amine, amide and nitro) in simple organic compounds and determination of their melting/boiling points.

Physical Chemistry **10 hrs**

(a) Titration of acetic acid against NaOH pH metrically.

(b) Determination of solubility and solubility product of a sparingly soluble salt (lead sulfate/ barium sulfate / silver chloride / calcium sulfate / lead chromate) by conductance measurement

(c) i) Determination of cell constant of a given cell.

ii) Determination of specific and equivalent conductance of the given electrolyte (NaCl) at different dilutions.

BOOKS RECOMMENDED:

- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Advanced Practical Inorganic Chemistry; Twenty Third Edition; GurdeepRaj,Goel Publishing House,Meerut, 2013.
- Advanced Practical Organic Chemistry,JagMohan, Himalaya Publishing House ,1992.

PAPER CODE- CHY 301
Inorganic Chemistry –II
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Explain the trends in physical and chemical properties and reactivity of d-block elements.
2. Acquaint students with the basic concepts of coordination chemistry and electronic configuration of the lanthanides and actinides including trends observed across the periodic table.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

CHY 301	**Inorganic Chemistry –II (Theory)**	**The students will be able to –** **CO40:** explain the fundamental concepts of coordination chemistry **CO41:** illustrate the physical and chemical composition of the transition metal complexes and compare various theories of coordination **CO42:** compare and analyze between the properties of first transition series (3d) with the second transition series (4d) and third transition series(5d) **CO43:** explain the properties of f-block elements, lanthanide contraction- its causes and consequences, actinide contraction, differences between lanthanides and actinides	▪ Interactive lectures ▪ Group discussions ▪ Peer teaching and learning ▪ Question preparation- Subjective type- Long answer &Short answer ▪ Objective type- Multiple choice questions ▪ One answer/two answer type questions ▪ Assertion and reasoning	▪ Class test ▪ Semester end examinations ▪ Quiz ▪ Solving problems in tutorials ▪ Assignments ▪ Presentation

CONTENTS

Unit I: Chemistry of Elements of First Transition Series **6 hrs**

Prerequisite: An elaborate idea of periodic table and electronic configurations

Introduction, electronicconfiguration, characteristic properties of d-block elements:Metallic character, variable oxidation states and their stability, density, melting point and boiling point, catalytic properties, ionization energies, magnetic properties and its origin, measurement of magnetic moments, colour, complexation tendencies.

Unit II : Chemistry of Elements of Second and Third Transition Series **5 hrs**

Electronic configuration, general characteristics, comparison of the elements of first transition series with second and third transition series with special reference to magnetic property, spectral property, stability of variable oxidation states and stereochemistry, ionic radii, complexation tendencies; metal-metal bonding and cluster compounds (elementary approach)

Unit III : Basic Concepts of Coordination Chemistry **6 hrs**

Introduction, Werner's coordination theory, concept of effective atomic number (EAN concept), classification of ligands, chelation, polynuclear complexes, IUPAC nomenclature of coordination compounds and methods of preparation of octahedral complexes of Fe, Co, and Ni(with monodentate ligands only), structure and bonding.

Unit IV : Models and Stereochemistry **6 hrs**

Isomerism in coordination compounds, structural isomerism and its types, stereochemistry of complexes of 4 and 6 coordination number, salient features of valence bond theory (VBT), structure of octahedral, tetrahedral and square planar complexes on the basis of VBT and its limitations.

Unit V : Chemistry of Inner-Transition Elements **7 hrs**

Lanthanides: Definition, position of lanthanides in the periodic table, separation of rare earth elements (solvent extraction and ion exchange method only), electronic configuration, physical properties, oxidation states, atomic and ionic radii, lanthanide contraction, causes and consequences of lanthanide contraction, magnetic and spectral properties; comparison between d- and f- block elements.

Actinides: Definition, position of actinides in the periodic table, electronic configuration, general characteristics of actinides and their comparison with lanthanides with special reference to magnetic properties, spectral properties and oxidation states.

BOOKS RECOMMENDED:

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; OxfordUniversity Press, New York, 2018.
- Nomenclature of Inorganic Chemistry – Recommendations – 1990; Edited by G.J. Leigh; Jain Interscience Press, Delhi, 1994.

PAPER CODE- CHY 302
Functionalized Organic Compounds-I
(Carbon-Halogen and Carbon- Oxygen/Sulphur Bonds)
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Learn about reaction and reactivity of some specific functional groups.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 302	**Functionalized Organic Compounds-I (Carbon-Halogen and Carbon-Oxygen/Sulphur Bonds) (Theory)**	**The students will be able to –** **CO44:** predict the products and stereochemistry of a nucleophilic substitution reaction/elimination reaction of an alkyl halide via different mechanisms SN1, SN2, E1 and E1 mechanism **CO45:** predict and explain the effect of alkyl, vinyl, aryl and allyl substituents on nucleophilic substitution. **CO46:** identify the effect of nucleophile, leaving group, substrate	▪ Interactive Lectures ▪ Group discussions ▪ Tutorials ▪ Quiz Problem solving sessions	▪ Multiple choice questions ▪ Assertions and reasoning ▪ Short answer questions ▪ Long answer questions ▪ Assignments

		and solvent on both substitution and elimination reactions and predict the predominant product **CO47:** understand the methods of formation and reactivities of various type of aliphatic alcohols (monohydric, dihydric and trihydric) and phenols **CO48:** compare the difference in acidity of aliphatic alcohols and phenols		▪ Quiz

CONTENTS

Unit I: Chemistry of Alkyl Halide **7 hrs**

Pre requisite: S_N2 and S_N1 reactions, Saytzeff's and Hoffmann rules

Substitution reactions: introduction, stereochemistry and factors affecting reactivity in substitution reactions.
Elimination reactions: introduction, β elimination reactions – E2 and E1 reactions, orientation in β elimination reactions.
Substitution v/s elimination.
Self Study: Methods of preparation,other important reactions of alkyl halides.

Unit II : Reactivity of Vinylic, Arylic, Allylic and Benzylic Substrates **6 hrs**

Lack of reactivity of vinyl and aryl halide under S_N1 andS_N2 condition, elimination reaction of vinyl halide. Nucleophilic substitution reaction of aryl halides: addition-elimination mechanism, elimination-addition (benzyne) mechanism; reactions involving allylic and benzyliccarbocations, allylic and benzylic S_N2 reactions.

Unit III : Monohydric Alcohols **6 hrs**

Introduction, classification**,** methods of formation by reduction of aldehydes, ketones, carboxylic acid and esters, biological oxidation of ethanol, hydrogen bonding, acidic nature-comparison with thiols, effect of solvents and polarity,reactions of alcohols

Unit IV : Dihydric and Trihydric Alcohols6 hrs

Method of preparation**,** chemical reactions of vicinal glycols, oxidative cleavage with $[Pb(OAc)_4]$ and HIO_4;Pinacol- Pinacolone rearrangement.
Trihydric alcohols: introduction, method of preparation andchemical reactions of glycerol
Self Study: Nomenclature

Unit V : Chemistry of Phenols **5 hrs**

Introduction, acidic character, comparative acidic strength of alcohol and phenol; reactions of phenols – electrophilic aromatic substitution, acylation and carboxylation, Fries rearrangement, Claisen rearrangement, Gattermann synthesis, Houben–Hoesch reaction, Lederer–Manasse reaction, Reimer-Tiemann reaction.
Self Study: Preparation of phenols.

BOOKS RECOMMENDED:

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York,2008.
- Organic Chemistry; Sixth Edition; G. Marc Loudon, J. Parise; WH Freeman, New York, 2015.

- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.
- Organic Chemistry.Vol. I and II;Second Edition; S.M. Mukherjee, S.P.Singh, R.P.Kapoorand R.Dass, New Age International Publishers,New Delhi,2017.

PAPER CODE- CHY 303
Applications of Thermodynamics
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Acquaint the students with the laws of thermodynamics in understanding homogenous and heterogenous equilibria.

2. Provide an in-depth knowledge of the concepts of electrochemistry in redox system.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 303	**Applications of Thermodynamics (Theory)**	**The students will be able to –** **CO49:** describe concept of Gibbs function, Helmholtz function and discuss their variation with pressure, volume and temperature. **CO50:** deduce the thermodynamic relations of equilibrium constant with other thermodynamic properties. **CO51:** explain heterogeneous equilibrium having one component and two component systems. **CO52:** predict the notation of a single electrode, cell and measure its cell potential using the Nernst equation. **CO53:** measure the thermodynamic properties of a cell using EMF. **CO54:** explain the operations of a concentration cell and predict the concentration in the cell based on the cell potential. **CO55:** measuring the pH of the given solution using various types of electrodes.	▪ Interactive Lectures ▪ Discussion ▪ Tutorials ▪ Multimedia Presentations ▪ Demonstration ▪ Learning activities for the students: ▪ Self learning Assignments ▪ Power Point Presentation ▪ Handouts	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed book and open book tests ▪ Quiz ▪ Problem solving exercises ▪ Assignments ▪ Presentation ▪ Semester End Examinations

CONTENTS

Unit I: Thermodynamics: Free energy functions 5 hrs

Gibbs and Helmholtz functions, Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A &G as criteria for thermodynamic equilibrium and spontaneity, their advantages over entropy change, variation of G & A with pressure, volumeandtemperature.

Unit II: Thermodynamics: Chemical equilibrium 6 hrs

Equilibrium constant and free energy, thermodynamic derivation of law of mass action. Le Chatelier'sprinciple,reaction isotherm and reaction isochore, Clapeyron equation, Clausius-Clapeyron equation and its applications.

Unit III: Heterogeneous equilibria – Phase rule 7 hrs

Introduction to phase, components and degree of freedom, derivation of Gibbs phase rule; phase equilibria of one component system-water, CO_2 and sulphur system.

Phase equilibria of two component system: Simple eutectic – Bi-Cd and Pb-Ag systems, desilverisation of lead.

Solid solutions: Compound formation with congruent melting point (Mg-Zn), ($FeCl_3$ – H_2O) and incongruent melting point (NaCl-H_2O)and ($CuSO_4$ – H_2O) system; freezing mixtures (acetone – dry ice).

UnitIV: **Electrochemistry I: Equilibrium in Redox System 5 hrs**

Types of reversible electrodes:Gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrodes, electrode reactions, Nernst equation, EMF of a cell and its measurement, computation of cell EMF, calculation of thermodynamic quantities of cell reactions (ΔG, ΔH & K), derivation of cell EMF and single electrode potential; standard hydrogen electrode- reference electrodes, standard electrode potential, sign conventions, electrochemical series and its significance.

Unit V: Electrochemistry II: Electromotive Force 7 hrs

Electrolytic and galvanic cells: Reversible and irreversible cells, conventional representation of electrochemical cells.

Concentration cell with and without transport, liquid junction potential, applications of concentration cell-valency of ions, solubility product, activity coefficient, potentiometric titrations.

Definition of pH and pKa, determination of pH using hydrogen, quinhydrone, glass electrodes and by potentiometric method

BOOKS RECOMMENDED:

- A Textbook of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.
- Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Second Edition;New Age International Pvt. Ltd, New Delhi, 2001.
- Physical Chemistry; G.M. Barrow; International Students Edition; McGraw Hill, New Delhi, 1994.
- Physical Chemistry; G.M. Barrow;Sixth Edition; McGraw Hill, New Delhi, 1994.

PAPER CODE- CHY 304
Laboratory Course
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Provide ample training in the synthesis of different inorganic complexes and identification of given organic compound.

2. Develop experimental skills of conductometry and thermochemistry.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 304	**Laboratory Course (Practical)**	**The students will be able to –** **CO56:** prepare inorganic complexes. **CO57:** deduce the given organic compound using functional group determination, MP measurement and derivative preparation. **CO58:** perform conductometric titrations using the basic knowledge of conductivity meter. **CO59:** measure enthalpy of neutralization and ionization for different acid-base combinations.	▪ Demonstration ▪ Discussion ▪ Presentations	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Quiz ▪ Presentation ▪ Individual and group projects

CONTENTS

Inorganic Chemistry

Synthesis **10 hrs**

a) Preparation of Prussian blue $Fe_4[Fe(CN)_6]_3$
b) Preparation of Sodiumtrioxalatoferrate (III)
c) Preparation of cis and trans-bisoxalatodiaquachromate (III).
d) Preparation of Bis-Dimethylglyoxime-nickel (II)
e) Preparation of Chloropentamminecobalt(III)chloride

Organic Chemistry **32 hrs**

Qualitative Analysis

Identification of an organic compound through the functional group analysis, determination of melting point/boiling point and preparation of suitable derivatives.

Physical Chemistry **18 hrs**

Thermochemistry

1. To determine the enthalpy of neutralisation of strong acid and strong base.
2. To determine the enthalpy of neutralization of weak acid/base versus strong base/acid and determine the enthalpy of ionization of weak acid/base.

Conductometry

To determine the strength of unknown acid (HCl/CH_3COOH) conductometrically using standard alkali solution.

BOOKS RECOMMENDED:

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.
- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Advanced Practical Inorganic Chemistry; Twenty Third Edition; GurdeepRaj,Goel Publishing House,Meerut 2013.
- Advanced Practical Organic Chemistry,Third Edition; N.K. Vishnoi; Vikas Publishing House, New Delhi, 2009.

PAPER CODE- CHY 401
Select Topics in Chemistry
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Make the students understand the basic concepts of acid and bases and non-aqueous solvents.
2. Enable the students to learn about the nuclear reactions and stability of nucleus.
3. Acquaint the students with the basic principles of analytical and chromatographic techniques

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 401	**Select Topics in Chemistry (Theory)**	**The students will be able to –** **CO60:** discriminate between various theories of acid and bases and identifytypes of acids and bases and compare acidity and basicity of different acid and bases. **CO61:** classify various types of solvents and differentiate between some non-aqueous solvents based on their properties and label different types of reactions in non-aqueous solvents **CO62:** develop an understanding of the concepts of nuclear models and categorize various nuclear reactions and compute nuclear stability parameters like binding energies and packing fraction and summarize different applications of radioactivity. **CO63:** differentiate between different types of errors and distinguish between accuracy and precision and calculate various types of deviations to express precision. Discuss principles and methods involved in gravimetric analysis **CO64:** describe principles and techniques of various types of chromatography.	▪ Class lectures ▪ Tutorials ▪ Group discussions ▪ Peer teaching and learning ▪ Question preparation ▪ Subjective type ▪ Long answer ▪ Short answer ▪ Objective type ▪ Multiple choice questions ▪ One answer/two answer type questions ▪ Assertion and reasoning	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed-book and open-book tests ▪ Problem-solving exercises ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I: Acids and Bases **5 hrs**

Arrhenius concept, Bronsted-Lowry theory, general theory of solvent system, Lewis acid-base concept, HSAB principle, its theories and applications.

UnitII : Non-aqueous Solvents **6 hrs**

Classification of solvents, physical properties of ionising solvents, water as universal solvent, liquid ammonia and liquid sulphur dioxide as solvent.

Unit III: Nuclear Chemistry **7 hrs**

Nuclear particles, Soddy-Fajans displacement law (group displacement law),nuclear forces:Forces operating between nucleons (n-n, p-p, n-p), quantitative idea of stability of nucleus, packing fraction, binding energy,nuclear reactions (fission and fusion reactions only),modes of decay,natural and artificial radio activity, transmutation, applications of radioactivity, nuclear models:Liquid drop model and shell model (elementary idea).

Self Study: Basics of fission and fusion reactions, half-life period, radioactivity.

UnitIV : Basic Principles of Analytical Techniques **6 hrs**

Data Analysis: errors in chemical analysis, classification of errors, accuracy and precision, minimization of errors,significant figures.Statistical analysis :Mean and standard deviation,Relative standard deviation,coefficient of variance, sampling in analysis, rejection of results, presentation of data.

Gravimetric analysis: Theory of precipitation, co-precipitation, post-precipitation from homogeneous solution and purification of precipitates.

Unit V: Chromatographic Technique and its applications **6 hrs**

Classification, basic principles of thin layer chromatography, paper chromatography, column chromatography, HPLC and Ion- Exchange chromatography, nature of adsorbent, solvent system, R_f values.

BOOKS RECOMMENDED:

- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Essentials of Nuclear Chemistry; Fourth Edition; H.J. Arnikar; New Age International(P) Ltd., New Delhi, 2011.
- Basic Concepts of Analytical Chemistry;Fourth Edition;S.M.Khopkar,New Age International Pvt Ltd, 2020.
- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Selected Topics in Inorganic Chemistry; W.U. Malik,G.D.Tuli , R.D. Madan; Sultan Chand & Sons,2004.

PAPER CODE- CHY 402
Functionalized Organic Compounds-II
(Carbonyl Compounds, Carboxylic Acids and its Derivatives)
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Make students learn how different compounds are prepared by the reactions of carbonyl moiety.
2. Introduce how the reactivity can be explained to allow the introduction of functional group next to carbonyl group.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 402	**Functionalized Organic Compounds-II (Carbonyl Compounds,**	**The students will be able to –** **CO65:** predict the reactivity of different carbonyl compounds (saturated and unsaturated	▪ Interactive Lectures ▪ Group Discussions ▪ Tutorials,	▪ Multiple choice questions ▪ Assertions and reasoning

	Carboxylic Acids and its Derivatives) (Theory)	aldehydes and ketones) and their methods of formation **CO66:** outline the nucleophilic addition reaction mechanism for carbonyl compounds **CO67:** recognize the mechanism and products in some name reactions following nucleophilic addition mechanism. **CO68:** describe the acidity and reactivity of active methylene groups **CO69:** discuss the synthesis of carboxylic acids and its derivatives from different substrates **CO70:** analyze the factors of the relative acidities of aliphatic and aromatic carboxylic acids by considering the inductive, resonance and steric effects on the neutral (conjugate acid) form and the anionic (conjugate base) form and compare with alcohols and phenols	▪ Quiz ▪ Problem solving sessions	▪ Short answer questions ▪ Long answer questions ▪ Assignments ▪ Quiz

CONTENTS

Unit I: Chemistry of Aldehydes and Ketones 7hrs

Synthesis from acid chlorides, 1,3-dithianes and enamines, nitriles and carboxylic acids;mechanism of nucleophilic addition reaction to carbonyl group with particular emphasis on Benzoin,Perkin, aldol, Knoevenagel condensation ,Reformatsky reaction and Dieckmancondensation,condensation with ammonia & its derivatives including reactions with primary & secondary amines, Mannich& Wittig reactions.

Unit II: Oxidation & Reduction of Aldehydes & Ketones 7 hrs

Use of acetals as protecting groups.Oxidation of aldehydes,Baeyer-Villiger oxidation of ketones,Oppenaueroxidation, Cannizzaro's reaction, MPV, Clemmensen,Wolff-Kishner, $LiAlH_4$, $NaBH_4$ reductions.

Unit III: Chemistry of Enolate ions, Enolsandα,β-Unsaturated Carbonyl Compounds 6 hrs

Introduction, acidity of α- hydrogens, keto-enoltautomerism of ethyl acetoacetate, evidences in favour of keto-enoltautomerism,synthesisofethylacetoacetate (Claisen condensation) and diethyl malonate, alkylation of ethylacetoacetate and diethyl malonate.

Unit IV: Chemistry of Carboxylic Acid 7 hrs

Pre requisite:Nomenclature, structure and physical properties, reduction of carboxylic acid to primary alcohol.
Acidity of carboxylic acids, effect of substituents on acidity; methods of preparation, reactions of carboxylic group, conversion of carboxylic acid into acid chlorides, anhydrides, amides, & esters, decarboxylation, Hell VolhardZelinsky reaction.

Unit V: Carboxylic Acid Derivatives: Esters, Acid chlorides, Amides and Anhydrides 5 hrs

Pre requisite: Nomenclature, preparation of carboxylic acid derivatives.

Basicity,relative stability of acyl derivative,physical properties , chemical reactions , mechanism of esterification & hydrolysis (acid & base catalysed),mechanism and reactivity in nucleophilic acyl substitution.

BOOKS RECOMMENDED:

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York,2008.
- Organic Chemistry; Sixth Edition; G. Marc Loudon, J. Parise; WH Freeman, New York, 2015.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.

PAPER CODE- CHY 403
Solutions and Reaction Kinetics
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Make the students understand the concept of ideal, non-ideal and partially miscible liquids.
2. Understand the concept of colligative properties of dilute solutions.
3. Provide an in-depth knowledge of experimental methods and theories of chemical kinetics.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 403	**Solutions and Reaction Kinetics (Theory)**	**The students will be able to –** **CO71:** describe the concept of solutions and partially miscible liquids. **CO72:** explain and apply colligative properties in molecular weight determination. **CO73:** calculate order of reaction and rate constant. **CO74:** compare various theories and experimental methods of chemical kinetics. **CO75:** explain adsorption isotherms and its applications.	▪ Interactive Lectures ▪ Discussions ▪ Tutorials ▪ Problem solving	▪ Presentations by Individual ▪ Student/ Group of Three ▪ Students ▪ Class Tests at Periodic ▪ Intervals. ▪ Written assignment(s) ▪ Semester End Examination

CONTENTS

Unit I:Solutions and Non-Ideal Solutions **7 hrs**

Solutions: Ideal and non-ideal solutions, distillation of solutions, lever rule, methods of expressing concentrations of solutions, activity and activity coefficient.
Solution of gases in liquid: Henry's law, deviation from Henry's law.
Solutions of solid in liquid- Nernst distribution law and its applications.
Non ideal system: Azeotropes, ethanol-water systems.
Partially miscible liquids: Phenol-water, trimethylamine-water, nicotine-water systems,
lower and upper consolute temperature, effect of impurity on consolute temperature, immiscible liquids, principle of steam distillation.
Self Study: Applications and limitations of Henry's law.

Unit II : Dilute Solutions– Colligative Properties **8hrs**

Introduction, colligative properties, Raoult's law, relative lowering of vapour pressure and its measurement,osmotic pressure and its measurement by Barkeley –Hartley's method, elevation of boiling point and its measurement by Landsberger's method, depression of freezing point and its measurement by Rast method, thermodynamic derivation using chemical potential to derive relation between the four colligative properties, use of colligative properties in molecular weight determination, non-ideal behaviour and van't Hoff's factor 'i'.
Self Study: Reverse osmosis.

Unit III: Chemical Kinetics **5hrs**

Chemical kinetics and its scope, rate of a reaction, factors influencing rate of a reaction, mathematical characteristics of simple chemical reactions- zero order, first order, second order, pseudo order, half life and mean life; determination of the order of reaction– differential, integration, half life period, radioactive decay as a first order phenomenon.
Self Study: Order, molecularity, rate law and rate constant.

Unit IV: Experimental Methods and Theories of Chemical Kinetics **6hrs**

Experimental methods of chemical kinetics– conductometry, polarimetry and spectrophotometry.
Arrhenius equation and activation energy.
Theories of chemical kinetics – collision theory and transition state theory.
Types of catalyst, specificity and selectivity, enzyme catalysis, Michalis-Menten mechanism.

Unit V: Surface chemistry **4hrs**

Adsorption at surfaces, physical and chemical adsorption, Freundlich, Langmuir and Gibbs adsorption isotherms, factors effecting adsorption, applications of adsorption.

BOOKS RECOMMENDED:

- A Textbook of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.
- Physical Chemistry Through Problems; Second Edition; S.K. Dogra and S.Dogra;New Age International Pvt. Ltd, New Delhi, 2001.

PAPER CODE- CHY 404
Laboratory Course
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. Understand the concept of quantitative analysis.
2. Learn the concept of chromatographic techniques.
3. Enable the students to acquire knowledge of kinetics and their calculations.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
CHY 404	Laboratory Course (Practical)	**The students will be able to –** **CO76:** determine different metal ions gravimetrically. **CO77:** learn the concept of chromatographic techniques and apply it to given problems. **CO78:** determine critical solution temperature of partially miscible liquids. **CO79:** calculate rate constant of different reactions. **CO80:** explain and apply the concept of transition temperature.	▪ Interactive Lectures ▪ Discussions ▪ Tutorials ▪ Problem solving	▪ Lab Tests and viva-voce at Periodic Intervals. ▪ Semester End Examination

CONTENTS

Inorganic Chemistry **24 hrs**

Quantitative Analysis: Gravimetric Analysis (Any Three)

a) Estimation of Cu as CuSCN,
b) Estimation of Zn as Zinc ammonium phosphate,
c) Estimation of Pb as $PbCrO_4$
d) Estimation of Ni as $Ni(DMG)_2$

Organic Chemistry **12hrs**

Chromatographic Techniques
Thin Layer Chromatography

a) Separation of 2,4 –dinitrophenylhydrazones of acetone, 2-butanone, hexan-2- one and hexane-3-one using toluene and light petroleum (40:60).
b) Separation of green leaf pigments (spinach leaves may be used).

Ascending paper chromatography
a) Separation of green leaf pigments (spinach leaves may be used).

Circular paper chromatography
a) Separation of amino acids or carbohydrates.

Physical Chemistry (Any four) **24 hrs**

a) To determine the mutual solubility curve for phenol – water system and their consolute point.

b) To study the effect of a solute (NaCl/succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the system.

c) To determine the transition temperature of given substance by thermometric method.

d) First order kinetics- Hydrolysis of methyl acetate catalyzed by HCl.

e) Second order kinetics- Saponification of ethyl acetate (initial concentration of both the reactants are same).

f) Determination of freezing point depression constant of camphor using Rast method.

BOOKS RECOMMENDED:

- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.
- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Organic Analytical Chemistry: Theory and Practice;JagMohan,Narosa Publishing House,New Delhi, 2014.

PAPER CODE- CHY 501
Transition Metal Complexes: Bonding and Spectra
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Make the students understand the basic concepts of acid and bases and non-aqueous solvents.
2. Enable the students to learn about the nuclear reactions and stability of nucleus.
3. Acquaint the students with the basic principles of analytical and chromatographic techniques

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
CHY 501	Transition Metal Complexes: Bonding and Spectra(Theory)	**The students will be able to –** **CO81:** distinguish between splitting pattern of orbitals for different geometries of complexes **CO82:** calculate CFSE for different geometries of complexes and discuss the cause and consequence of Jahn Teller and list out the applications of CFT **CO83:** differentiate between different types of magnetic behavior and interpret magnetic moments for different complexes **CO84:** describe L-S coupling and compute ground state terms and employ selection rules and sketch orgel diagrams and discuss electronic spectra **CO85:** define stability of complexes and compare thermodynamic with kinetic stability of complexes and explain trans effect and its applications	▪ Class lectures ▪ Tutorials ▪ Group discussions ▪ Peer teaching and learning ▪ Question preparation ▪ Subjective type ▪ Long answer ▪ Short answer ▪ Objective type ▪ Multiple choice questions ▪ type questions ▪ Assertion and One answer/two answer ▪ reasoning	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed-book and open-book tests ▪ Problem-solving exercises ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I: Metal-ligand Bonding in Transition Metal Complexes –I **7 hrs**

Prerequisite: Valence bond theory.

Crystal Field Theory- Important postulates, crystal field splitting of d-orbitals in octahedral and tetrahedral complexes, factors affecting the magnitude of Δ_0, calculation of crystal field stabilization energy,strong and weak ligands, spectrochemical series,distribution of d-electrons in t_{2g} and e_g orbitals in octahedral and tetrahedral complexes.

Unit II: Metal-ligand Bonding in Transition Metal Complexes –II **6 hrs**

Distortion of octahedral complexes, crystal field splitting of d-orbitals in square planar complexes and Jahn Teller theorem.Use of CFSE values, number of unpaired electrons and high spin (HS) and low spin (LS) complexes, applications and limitations of CFT.

Unit III: Magnetic Properties of Transition Metal Complexes **4hrs**

Prerequisite: Types of magnetism.

Types of magnetic behaviour, methods of determining magnetic susceptibility, spin only formula, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments,
applications of magnetic moment data for 3d-complexes.

Unit IV : Electronic Spectra of Transition Metal Complexes 7 hrs

Types of electronic transitions,coupling of orbital angular momenta and spin angular momenta (in p^2 and d^2 configuration), spin orbit coupling/LS coupling, determining the ground state terms, Hund's rule, hole formulation, calculation of the number of micro states,selection rules- Laporte 'orbital' selection rule, spin selection rule, spectroscopic ground states. Orgel energy level diagram for d^1&d^9 states, discussion of electronic spectrum of $[Ti(H_2O)_6]^{+3}$ complex.

Unit V: Thermodynamic and Kinetic Stability of Metal Complexes 6 hrs

Definition of stability, stepwise and overall formation constants, kinetic v/s thermodynamic stability, labile and inert complexes, factors affecting the stability of complexes, trans-effect, theories and its uses, mechanism of substitution reactions in square planar complexes, trans-effect, theories of trans-effect and its uses.

BOOKS RECOMMENDED:

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Inorganic Chemistry; Fifth Edition; A. G. Sharpe, C.E. Housecraft; Pearson Education, England, 2018.
- Concepts and Models of Inorganic Chemistry; Third Edition; Bodie Douglas, Darl McDaniel, John Alexander; John Wiley and Sons, Singapore, 2001.
- General and Inorganic Chemistry Part I & II; Third Edition, R. Sarkar, New Central Book Agency Ltd, 2011.
- Coordination Chemistry; D. Banerjea; Tata Mc Graw Hill Publishing Company Limited, New Delhi, 1993.

PAPER CODE- CHY 502
Biomolecules, Dyes and Spectral Techniques
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Endow the students with the knowledge of the structure-function relationship and importance of biomolecules in perpetuation of living systems.

2. Briefs them about the utility of synthetic dyes and spectral techniques.

Course Outcomes (COs):

Course	Learning outcomes		

Paper Code	Paper Title	(at course level)	Learning and teaching strategies	Assessment Strategies
CHY 502	**Biomolecules, Dyes and Spectral Techniques (Theory)**	**The students will be able to –** **CO86:** summarize the functions of amino acids & proteins and identify the influence of the three-dimensional shape and subunits of a protein on its function **CO87:** identify the chemical elements and functions of carbohydrates and differentiate between simple and complex structures of the same **CO88:** describe the preparations, properties and applications of synthetic dyes in commercial capacity **CO89:** predict the λmax for different organic compounds using Woodward-Feiser rules **CO90:** employ the theoretical knowledge & selection rules of IR in spectral analysis of simple compounds	▪ Interactive Lectures ▪ Discussions ▪ Tutorials ▪ Quiz ▪ Problem solving	▪ Continuous Assessment(Written test) ▪ Quiz ▪ Closed-book and open-book tests ▪ Assignment ▪ Group Activity ▪ Semester End Exam

CONTENTS

Unit I:Proteins and Amino Acids **6 hrs**

Amino acids: classification, structure and stereochemistry, acid base behaviour, isoelectric point, electrophoresis, preparation and reactions of α-amino acids.
Proteins: Peptide linkages, structure and classification of primary, secondary and tertiary proteins and denaturation.
Nucleic acids: Introduction, protein synthesis, functions.

Self Study: Structure of nucleic acids, ribonucleosides and ribonucleotides, double helical structure of DNA.

Unit II: Carbohydrates **7 hrs**

Classification and nomenclature, monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses, configuration of monosaccharides, erythro and threodiastereomers, conversion of glucose into mannose. formation of glycosides, ethers and esters, determination of ring size of monosaccharides, cyclic structure of D-(+)-glucose , mechanism of mutarotation

Unit III: Synthetic Dyes **5hrs**

Colour and constitution (electronic concept), classification of dyes, chemistry and synthesis of methyl orange, congo red, malachite green, crystal violet, phenolphthalein, fluorescein, alizarin and indigo.

UnitIV : Ultraviolet Spectroscopy **6 hrs**

Electromagnetic radiation, quantization of energy, regions of electromagnetic spectrum,
Lambert – Beer law, molar absorptivity, different electronic transitions and symmetry rules, effect of solvent on transitions, effect of conjugation, concept of chromophores and auxochromes, bathochromic, hypsochromic, hyperchromic and hypochromic shift. Woodward Fieser rules and its applications on enes, dienes, α,β-unsaturated carbonyls and extended conjugations.

Unit V: Infrared Spectroscopy **6hrs**

Molecular vibrations, Hooke's law, different regions of IR spectrum (finger print and functional group region), selection rules, characteristic intensity and position of IR bands of various functional groups

(alkanes, alkenes, alkyl halides, alcohols, ethers, carbonyl compounds, primary and secondary amines, carboxylic acids and its derivatives); effect of solvent and hydrogen bonding.

BOOKS RECOMMENDED:

- Organic Chemistry, Vol 2; Sixth Edition; I.L. Finar; Pearson Education, New Delhi, 2002.
- Spectroscopy of Organic Compounds; Sixth Edition; P.S. Kalsi; New Age International (P) Ltd Publishers, New Delhi, 2016.

PAPER CODE- CHY 503
Introduction to Quantum Mechanics
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Learn principal concepts of quantum mechanics.
2. Establish relationship between physical properties and molecular structure.
3. Understand basic concept and applications of computational chemistry.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 503	**Introduction to Quantum Mechanics (Theory)**	**The students will be able to –** **CO91:** identify limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems. **CO92:** develop an understanding of quantum mechanical operators, quantization, probability distribution. **CO93:** describe Schrodinger's wave equation for hydrogen atom and separate it in to three component equations. **CO94:** normalize simple wave function and calculate average physical property for system like energy, momentum etc.	▪ Interactive Lectures ▪ Discussion ▪ Tutorials ▪ Reading assignments ▪ Demonstration ▪ Revision in form of interactive quiz	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed-book and open-book tests ▪ Problem-solving exercises ▪ Assignments ▪ Quiz

		CO95: describe chemical bonding theories in quantum mechanical approach. **CO96:** learn the basic concepts of computational chemistry.		▪ Semester End Examination

CONTENTS

Unit I: Elementary Quantum Mechanics **7 hrs**

Black-body radiation, Planck's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect, de Broglie hypothesis, Heisenberg's uncertainty principle, heat capacity of solids.

Sinusoidal wave equation, operators, Hamiltonian operator, eigen function, eigen values, Schrodinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics.

Unit II : Applications of Quantum Mechanics **6 hrs**

Particle in one dimensional and its extension to threedimensional box, Schrodinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial and angular wave functions, selection rule and spectra of Hydrogen atom

Unit III : Chemical bond: A Quantum Approach **9 hrs**

Concept of σ, σ^*, π, π^* orbitals and their characteristics, introduction to valence bond model of H_2, comparison of M.O. and V.B. models, molecular orbital theory, basic ideas- criteria for forming M.O.'s from A.O.'s, construction of M.O's by LCAO (H_2^+ ion), calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, hybrid orbitals – sp, sp^2, sp^3, calculation of coefficients of A.O.'s used in these hybrid orbitals.

Unit IV: Polarization **4hrs**

Dipole moment, induced dipole moment,orientation of dipoles in an electric field, dipole moment and structure of molecules, Clausius-Mossotti equation, measurement of dipole moment- temperature method and refractivity method.

Unit V :An Introduction to Computational Chemistry **5 hrs**

An overview of computational chemistry, molecular mechanics, electronic structure method, semi-empirical, ab initio and density functional methods, principle of model chemistry, desirable features of a model chemistry.

BOOKS RECOMMENDED:

- A Textbook of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.

- Quantum Chemistry Including Molecular Spectroscopy; Fourth Edition; B.K. Sen; Tata McGraw-Hill, Publishing Company Ltd, New Delhi, 2011.
- Introductory Quantum Chemistry; Fourth Edition A. K.Chandra; Tata McGraw-Hill, 2017.
- Quantum Chemistry; Fourth Edition; R.K. Prasad; New Age International (P) Ltd, New Delhi, 2009.
- Physical Chemistry Through Problems; Second Edition;S.K. Dogra and S.Dogra; New Age International Pvt. Ltd, New Delhi, 2001.
- Exploring Chemistry with Electronic Structure Methods; Second Edition; James B. Foresman and A. Frisch, Gaussian, Inc. Pittsburg, 1996.

PAPER CODE- CHY 504
Laboratory Course
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. Make the students understand the core concepts of organic mixture analysis.

2. Develop quantitative and qualitative skills and useful techniques for different analytical purposes.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 504	**Laboratory Course (Practical)**	**The students will be able to –** **CO97:**apply suitable techniques to separate an organic mixture with safety. **CO98:** document the results obtained through the writing of lab reports. **CO99:** learn the spectrophotometric technique.	▪ Demonstrations ▪ Tutorials ▪ Group discussion	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Problem-solving exercises ▪ Quiz ▪ Practical Files ▪ Semester End Examination

CONTENTS

Organic Chemistry **40 hrs**

Qualitative Analysis
Separation and identification of solid binary mixture using water/$NaHCO_3$ /NaOH and preparation of suitable derivatives.

Physical / Analytical Chemistry **20 hrs**

Colorimetry

a) Record an absorption spectrum of a substance ($KMnO_4/K_2Cr_2O_7$) using a spectrophotometer and determine absorption maxima (λ_{max}).
b) To verify the Beer-Lambert law for a compound(potassium permanganate, copper sulphate, methylene blue etc.) and determine the concentration of the substance using calibration curve.
c) Detection of adulteration of food stuffs - To detect the total dye content in sunset yellow colour
d) Water analysis- analysis of phosphorus in water.
e) Job's method of continuous variation by iron-phenanthroline complex.
f) Mole ratio method by iron-phenanthroline complex.

Polarimeter

To determine the specific rotation /unknown concentration of an optically active compound (glucose/sucrose)

Adsorption

To study the adsorption of a solute (acetic acid) on a dispersed solid (activated charcoal).

BOOKS RECOMMENDED:

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.
- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Organic Analytical Chemistry: Theory and Practice;JagMohan,Narosa Publishing House,New Delhi, 2014.

PAPER CODE- CHY 601
Organometallics, Bio-inorganic and Polymers
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Make students understand about the basics of organometallic chemistry, structure and nature of bonding in metal carbonyls and nitrosyls, vitality of metal ions in biosystems and importance of organic and inorganic polymers.

Course Outcomes (COs):

Course	Learning outcomes (at course level)		Assessment Strategies

Paper Code	Paper Title		Learning and teaching strategies	
CHY 601	**Organometallics, Bio-inorganic and Polymers (Theory)**	**The students will be able to –** **CO100:** learn the classification, identify organometallic compound and provide the IUPAC nomenclature. **CO101:** explain the mechanism of homogeneous hydrogenation and polymerization using organometallic catalyst **CO102:** interpret the structure and bonding involved in metallic carbonyls and nitrosyls **CO103:** differentiate between bulk and trace elements and explain the importance of metal ions in biological systems. **CO104:** classify the types of organic polymers and compare the preparation and properties of the above two	▪ Class lectures ▪ Tutorials ▪ Group discussions ▪ Peer teaching and learning ▪ Question preparation ▪ Subjective type ▪ Long answer ▪ Short answer ▪ Objective type ▪ Multiple choice questions ▪ One answer/two answer type questions ▪ Assertion and reasoning	▪ The oral and written examinations (Scheduled and surprise tests) ▪ Closed-book and open-book tests ▪ Problem-solving exercises ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I: Organometallic Chemistry **7 hrs**

Definition, nomenclature and classification of organometallic compounds.General characteristics, preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti,metal ethylenic complex – Zeise's salt (brief idea). Hydrogenation and polymerization of alkene by organotransition metal complex (an elementary concept).

Unit II : Metal Carbonyls and Nitrosyls **6 hrs**

Introduction to π acceptor ligands.Definition, classification, general methods of preparation, properties, structure and nature of bonding in metal carbonyls (mononuclear carbonyls only).
Metal nitrosyls: preparation, structure and nature of bonding.

Unit III: Bio-inorganic Chemistry **5 hrs**

The biological role of metal ions- Na, K (Sodium potassium pump), Ca, Mg (Chlorophyll structure and function), Zn (Carboxypeptidase and Carbonic anhydrase- structure and function), Metalloporphyrins with special reference to hemoglobin and myoglobin.

Unit IV: Polymers-I **6 hrs**

Types, comparison with organic polymers, synthesis, structural aspects and applications of silicones, phosphazenes, and tetrasulphurtetranitride.

Unit V: Polymers-II 6**hrs**

Classification, condensation and addition polymerizations – Mechanism of free radical, cationic, anionic addition polymerization, Ziegler-Natta catalyzed reactions, stereochemistry and kinetics,vinyl polymers (PVC, poly vinyl acetate, polystyrene), teflon, urea-formaldehyde resin and phenol-formaldehyde resins, polyurethanes, synthetic fibers– Nylon-66, nylon-6, polyester, polyacrylicfibers, plasticizers,natural and synthetic rubber, vulcanization.

BOOKS RECOMMENDED:

- Organometallic Chemistry: A Unified Approach; Second Edition; R.C. Mehrotra and A.Singh; New Age International Private Limited, New Delhi, 2000.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Polymers; David Walton and Philip Lorimer; Oxford University Press, 2001.
- Introduction to Polymers; Third Edition R.J. Young and P.A. Lovell; Nelson Thornes, United Kingdom, 2011.
- Inorganic and Organometallic Polymers; Vadapalli Chandrasekhar, Springer, BerlinHeidelberg, New York, 2005.

PAPER CODE- CHY 602
Nitrogen Containing Organic Compounds and Some Aspects of- Medicinal Chemistry (Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Enrich the learners with the ability to compare the effect of heteroatoms on structure and reactivity of simple and benzofuzed aromatic compounds and to touch up on the exclusive chemistry of nitrogen containing functional groups.

2. Helps them gain perspective on different classes of chemotherapeutic agents.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 602	**Nitrogen Containing Organic Compounds and Some Aspects of- Medicinal Chemistry (Theory)**	**The students will be able to –** **CO105:** describe the structural and chemical properties of five and six membered aromatic heterocycles **CO106:** learn the preparations and reaction mechanisms of benzofuzed heterocycles **CO107:** discuss the formation and reactivity of aliphatic as well as aromatic nitro compounds **CO108:** differentiate between 1°/2°/3° amines and discuss their role in acting as a base, phase transfer	▪ Interactive Lectures ▪ Discussions ▪ Tutorials ▪ Quiz ▪ Problem solving	▪ Continuous Assessment(Written test) ▪ Quiz ▪ Closed-book and open-book tests ▪ Assignment ▪ Group Activity ▪ Semester End Exam

		catalyst and as a precursor to diazotization **CO109:** classify chemotherapeutic agents on the basis of their medicinal applications and define their structure, function and synthesis.		

CONTENTS

Unit I: Heterocyclic Compounds **7 hrs**

Nomenclature of five and six membered heterocycles; molecular orbital picture and aromatic character of pyrrole , pyridine, furan and thiophene; methods of synthesis, chemical reactions with respect to electrophilic substitution reactions, nucleophilic substitution reactions in pyridine and pyrrole (mechanism and orientation), comparisonofbasicity of pyridine,piperidineand pyrrole.

Unit II : Condensed Five and Six Membered Heterocycles **5 hrs**

Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer indole synthesis, Skraup synthesis and Bischler – Napieralski synthesis.

Unit III : Nitroarenes **5 hrs**

Pre requisite: Aliphatic nitro compounds.

Preparation, reactions – electrophilic and nucleophilic substitution, effect of the substituents on the acidity of phenols, effect of nitro group on nucleophilic substitution of aryl halides, reduction.

Unit IV : Amines **6 hrs**

Nomenclature**,**preparation and reactions of aliphatic and aromatic primary amines.

Classification and distinction between primary, secondary and tertiary amines; relative basic strength of aliphatic and aromatic amines; diazotization- mechanism, stability of diazonium salts,

Self Study:diazo coupling

Unit V: Drugs and Antibiotics **7 hrs**

Introduction, lock and key theory

Synthesis and medicinal applications of -Sulpha drugs: sulphadiazine (sulpha pyrimidine), sulpha guanidine, sulphamethazine, sulpha pyridine.

Analgesics: aspirin, phenacetin, paracetamol.

Antimalarials: chloroquine, pamaquine.

Antibiotics: penicillin, streptomycin and chloramphenicol.

BOOKS RECOMMENDED:

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York, 2008.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.
- Organic Chemistry Vol. I and II ; Sixth Edition; I.L. Finar; Pearson Education, New Delhi, 2002.

PAPER CODE- CHY 603
Spectroscopy and Photochemical Laws
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Aware the students with the principles and applications of rotational, vibrational, Raman, electronic and NMR spectroscopy techniques.
2. Provide the knowledge about various processes involved during interaction of radiation with matter

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 603	**Spectroscopy and Photochemical Laws (Theory)**	**The students will be able to –** **CO110:** discuss qualitative and quantitative knowledge of the fundamental concepts of spectroscopy. **CO111:** describe principle, selection rules and applications of rotational, vibrational, Raman, electronic and NMR spectroscopy. **CO112:** apply spectroscopic data for molecular characterization. **CO113:** outline fundamentals of photochemistry and laws governing it. **CO114:** evaluate the various deactivation processes of molecular excited states.	▪ Interactive Lectures, ▪ Explicit Teaching ▪ Discussion ▪ Didactic questions ▪ Tutorials ▪ Multimedia Presentations ▪ Demonstration ▪ Learning activities for the students: ▪ Self learning Assignments ▪ Peer Assessment ▪ Concept mapping ▪ Think/Pair/Share, Problem Solving, Power Point Presentation, Handouts	▪ The oral and written examinations(Scheduled and surprise tests) ▪ Closed book and open book tests ▪ Quiz ▪ Problem solving exercises ▪ Assignments ▪ Presentation ▪ Semester End Examinations

CONTENTS

Unit I: Rotational Spectrum **6 hrs**

Diatomic molecule, energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution), determination of bond length, qualitative description of non-rigid rotor, isotope effect, Born –Oppenheimer approximation.

UnitII : Vibrational Spectrum **7 hrs**

Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant, qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups,rotational- vibrational spectrum.

Raman spectrum: Concept of polarizability, pure rotational Raman and pure vibrational Raman spectra of diatomic molecules, selection rules**.**

Unit III: Electronic Spectrum **6 hrs**

Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Franck–Condon principle, qualitative description of σ, π and n molecular orbitals, their energy levels and respective transitions.

Unit IV: Nuclear Magnetic Resonance Spectroscopy **5 hrs**

Introduction, principle of nuclear magnetic resonance, nuclear shielding and deshielding, energies of nuclei in magnetic fields, technique, chemical shift, spin-spin coupling and coupling constant, proton spectra of simple compounds like ethanol, ethyl acetate, 1,2-dibromoethane.

Unit V : Photochemistry **6 hrs**

Interaction of radiation with matter, difference between thermal and photochemical processes, laws of photochemistry: Grotthuss–Draper law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing); quantum yield, energy transfer processes – Photosensitization.

BOOKS RECOMMENDED:

- Textbook of Physical Chemistry; Second edition;A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Fundamentals of Molecular Spectroscopy, Fourth Edition; C.N. Banwell& Mc Cash.; Tata McGraw-Hill, New Delhi, 2017.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry Through Problems; Second Edition; S.K. Dogra and S.Dogra;New Age International Pvt. Ltd, New Delhi, 2001.

PAPER CODE- CHY 604
Laboratory Course
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. Make the students understand the core concepts of green synthesis.
2. Provide the knowledge about various spectral techniques.
3. Develop quantitative skills for different analytical purposes.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 604	**Laboratory Course(Practical)**	**The students will be able to –** **CO115:** learn the use of green chemistry principles and processes in laboratory reactions as a benign approach. **CO116:** compare the advantages of green procedures over conventional synthesis. **CO117:** assign structures to simple molecules on the basis of infra-red and nuclear magnetic resonance spectroscopy. **CO118:** estimate the different functional groups i.e. hydroxyl (monohydric, dihydric, trihydric and phenols) and amino by different methods. **CO119:** estimate the saponification value of different saturated and unsaturated oil.	▪ Demonstrations ▪ Viva ▪ Interactive lectures	▪ Lab experiments ▪ Records ▪ Viva ▪ Group discussions ▪ Quiz

CONTENTS

Organic Chemistry **36 hrs**

Synthesis (Green /Conventional)
a) **Aromatic Electrophilic Substitution**
i) Acetylation – Acetylation of aniline/salicylic acid.
ii) Nitration - Preparation of 4-nitrosalicylic acid
ii) Bromination - Preparation of p-bromoacetanilide

b) **Aldol Condensation:**Synthesis of dibenzal propanone
c) Rearrangement: Benzil-Benzilic acid rearrangement
d) **Pechmann Condensation for Coumarin synthesis**: Clay catalysed solid state synthesis of 7-hydroxy -4- methyl coumarin
e) **Diazotization/coupling**: Preparation of methyl orange

Spectroscopy: Interpretation of IR and NMR spectra of simple organic compounds (ethanol, 1-propanol, 2-propanol, methylethanoate, ethyl acetate,stilbene, ethyl acetate, propanone etc).

Quantitative Analysis12 hrs

a) To determine the neutralization equivalent of the acid.
b) Estimation of glucose by Fehling's /Benedict solution
c) Estimation of saponification value of the given oil.

BOOKS RECOMMENDED:

- University Practical Chemistry; Second Edition;P.C.Kamboj, Vishal Publishing House,New Delhi, 2019.
- Monograph green chemistry laboratory experiments-Laboratory Task Force Committee, DST.
- Comprehensive practical organic chemistry; V.K.Ahluwalia and Renu Aggarwal; University press (India) Pvt. Ltd, 2013.
- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar,
- J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford,
- P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.
- Experimental Organic Chemistry, Volume I; P.R.Singh, D.S. Gupta, K.S. Bajpai; Tata McGraw
- Hill Publishing Company Ltd., New Delhi, 1982.

Programme- B.Sc. (H) Chemistry

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	**Innovative.** Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	**Critical thinking and Problem Solving:** Employ critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	**Employability:** Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	**Collaborative:** Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology.
PO5	**Applicability:** Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	**Research Aptitude:** Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports.
PO7	**Sustainable Development**: Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread

	knowledge, creating awareness about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	**Communication Skills:** Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO9	**Ethics:** Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	**Life-long learning:** Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	**Leadership readiness:** Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	**Instrumentation:** Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. They will have extensive laboratory work and knowledge of Biological Chemistry.
PSO 2	Develop critical thinking and analytical reasoning as applied to scientific problems.
PSO 3	Develop skill in problem solving where the learner will develop the capability to function as a member of an problem solving team. The learner will be capable to – identify the issues. list the possible solutions (options) evaluate the options select a correct option(s)
PSO 4	Appreciate the understanding of safe handling of chemicals, toxic hazards, long term health effects from chemicals and environmental issues.
PSO 5	Foster the ability to focus different minds on the same problem, mutual support, commitment, accountability, conflict management, trust, focusing on results and increased efficiency in their personality.
PSO 6	Initiate, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.
PSO 7	Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
PSO 8	Keenly observe about what is going on in the natural surroundings to awake their curiosity, design a scientific experiment through statistical hypothesis testing and can take ethical decisions, designate moral situations and dilemmas; critically analyze, evaluate, and additionally change one's own moral and ethical esteems; and look up the effects of one's own attitude for the lives of others.
PSO 9	Understand documents with in-depth analyses and logical arguments and can clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH POS)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CHY-111	CO1	x								x
	CO2		X	x		x				
	CO3	x	X							
	CO4									x
	CO5	x					X			
	CO6	x				x				x
CHY-112	CO7		X	x			X			
	CO8	x					X			x
	CO9	x	X				X		x	
	CO10			x			X		x	
CHY-113	CO11	X	X	x		x				
	CO12	X	X	x			X			
	CO13	X	X	x						x
	CO14	X		x			X			x
	CO15	X		x			X			
	CO16	X	X	x			X		x	
	CO17	X	X	x						x
CHY-114	CO18	X					X			
	CO19	X					X	x		
	CO20		x	x			X			
	CO21			x			X	x	x	
	CO22			x			X	x		
	CO23		x	x			X		x	
CHY-115	CO24	x			x	x				
	CO25	x				x	X		x	
	CO26	x			x	x	X		x	
CHY-116	CO27	x			x	x				
	CO28	x			x	x				
CHY-211	CO29	x								x
	CO30		x	x						
	CO31	x					X			
	CO32	x							x	
	CO33	x						x	x	
CHY-212	CO34	x	x							
	CO35		x	x			X			
	CO36	x								x
	CO37	x								x
	CO38			x			X		x	
	CO39	x					X			
	CO40	x							x	
CHY-213	CO41	x								x

	CO42	x		x		x	X			
	CO43	x		x						x
	CO44	x	X				X			x
	CO45	x						x		
	CO46	x	X							
CHY-214(a)	**CO47**		X	x				x		
	CO48		X	x				x		
	CO49	x	X	x			X	x		
	CO50		X	x				x		
	CO51		X	x			X			
CHY-214(b)	**CO52**	x					X			
	CO53	x								x
	CO54	x								
	CO55	x								x
	CO56	x							x	
CHY-215	**CO57**	x			x	x				
	CO58	x			x	x	X			
	CO59	x			x	x			x	
	CO60	x			x	x		x		
CHY-216	**CO61**	x			x	x				x
	CO62	x			x	x	X			
	CO63	x		x	x	x				
	CO64	x			x	x			x	
CHY-311	**CO65**	x								x
	CO66	x					X		x	
	CO67	x								x
	CO68	x	X				X		x	
CHY-312	**CO69**	x					X			x
	CO70	x								
	CO71		X				X		x	
	CO72	x		x			X		x	x
	CO73	x					X			
	CO74	x	X						x	x
CHY-313	**CO75**	x								x
	CO76	x				x	X			x
	CO77	x								x
	CO78	x		x						
	CO79	x	X	x						
	CO80	x					X		x	
CHY-314	**CO81**	x	X							
	CO82	x	X							
	CO83	x								
	CO84	x							x	
	CO85	x	X	x			X			
	CO86	x					X			

CHY-315	**CO87**	x		x	x	x				
	CO88	x				x		x		x
	CO89	x				x				x
	CO90	x			x	x			x	
	CO91	x			x	x		x	x	
	CO92	x			x	x			x	
CHY-316	**CO93**					x				x
	CO94	x					X			
	CO95	x					X			
	CO96	x	X						x	
CHY-411	**CO97**	x								
	CO98	x	X	x			X			
	CO99	x	X							
	CO100	x	X	x			X			x
	CO101	x	X	x					x	
	CO102	x				x				x
CHY-412	**CO103**	x								
	CO104	x								
	CO105	x					X		x	
	CO106	x								x
	CO107	x								x
CHY-413	**CO108**	x								x
	CO109		X	x						
	CO110	x					X			
	CO111	x								x
	CO112	x	X						x	
CHY-414	**CO113**	x		x	x	x			x	
	CO114	x		x	x	x			x	x
	CO115	x		x	x	x			x	
	CO116	x		x	x	x			x	x
	CO117	x		x	x	x			x	
CHY-415	**CO118**	x		x		x			x	
	CO119	x				x			x	
	CO120	x	X	x		x			x	
CHY-416	**CO121**	x		x		x			x	
	CO122	x	X	x		x			x	
	CO123	x				x			x	
	CO124	x				x			x	
CHY-511	**CO125**	x								x
	CO126	x				x				x
	CO127	x	X	x						
	CO128	x	X							
	CO129	x								
	CO130	x							x	

CHY-512	**CO131**	x				x				x
	CO132	x								
	CO133	x							x	
	CO134	x								x
	CO135	x					X			
CHY-513	**CO136**	x								
	CO137	x								
	CO138	x						x		
	CO139		X	x				x		
	CO140	x		x						
	CO141	x								x
	CO142	x							x	
CHY-514	**CO143**	x							x	
	CO144						X		x	x
	CO145			x			X	x	x	
	CO146						X		x	
CHY-515	**CO147**	x			x		X		x	x
	CO148	x			x				x	
CHY-516	**CO149**	x							x	x
	CO150	x					X		x	
	CO151	x					X		x	
	CO152	x		x			X		x	
CHY-611	**CO153**	X	X	x						
	CO154		X	x						
	CO155	X				x				x
	CO156	X					X			x
	CO157	X								
CHY-612	**CO158**	X					X			
	CO159	X					X			
	CO160	X	X	x			X			
	CO161	X	X	x						
	CO162	X	X	x					x	
	CO163	X	X				X		x	
CHY-613	**CO164**	X				x				x
	CO165	X								x
	CO166		X					x	x	
	CO167			x				x		
	CO168		X							
CHY-614	**CO169**	X				x				x
	CO170		X				X			
	CO171			x						
	CO172	X	X				X		x	x
	CO173		X				X			
CHY-615	**CO174**			x	x					

	CO175			x	x					
	CO176			x	x					
	CO177			x	x		X		x	
CHY-616	**CO178**	X			x					
	CO179	X			x		X		x	
	CO180		X		x				x	
	CO181				x			x	x	

B.Sc. (H) CHEMISTRY (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE- CHY 111
Inorganic Chemistry I
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. provide an in-depth knowledge about different types of bonding in main group elements.
2. acquaint the students with the concept of hybridization and geometry of covalent molecules, shapes of atomic and molecular orbitals

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-111	**Inorganic Chemistry**	**The students will be able to –** **CO1:** explain scientific theory of atoms and concept of wave function and quantum numbers **CO2**: calculate the radius ratio of ionic molecules and determine the ionic structures, apply the concept of Born-Haber cycle in predicting the lattice energy, ionization energy and stability of the ionic compounds. **CO3:** predict physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table. **CO4**: describe the various types of hybridization Develop a comprehensive understanding of various ecological processes and environmental issues	Class lectures • Tutorials • Group discussions • Model Study • Question preparation Subjective type ▪ Long answer ▪ Short answer Objective type ▪Multiple choice questions ▪One answer/two answer type questions • Assertion and reasoning	The oral and written examinations (Scheduled and surprise tests) • Closed-book and open book tests •Problem solving exercises •Assignments •Quiz •Semester End Examination

CONTENTS

Unit I: Atomic Structure **10Hrs**

Bohr's theory to hydrogen-like atoms and ions; spectrum of hydrogen atom. Quantum numbers. Introduction to the concept of atomic orbitals; shapes, radial and angular probability diagrams of s, p and d orbitals (qualitative idea). Many electron atoms and ions: Pauli's exclusion principle, Hund's rule, exchange energy, Aufbau principle and its limitation. Electronic energy level diagram and electronic configurations of hydrogen-like and polyelectronic atoms and ions up to atomic number

Unit II: Chemical Periodicity **12Hrs**

Periodic table, group trends and periodic trends in physical properties.Classification of elements on the basis of electronic configuration. Modern IUPAC Periodic table. General characteristic of s, p, d and f block elements. Position of hydrogen and noble gases in the periodic table. Effective nuclear charges, screening effects, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii. Ionization potential, electron affinity and electronegativity (Pauling, Mulliken and Allred-Rochow scales) and factors influencing these properties. Inert pair effect.

UNIT III: Ionic Bonding **7Hrs**

Size effects, radius ratio rules and their limitations. Packing of ions in crystals, ionic compounds of the type AX (ZnS, NaCl, CsCl) and AX_2 (CaF_2-fluorite) lattice energy, Born–Landéequation and its applications, Born-Haber cycle and its applications. Solvation energy, polarizing power and polarizability, ionic potential,Fajans' rules. Defects in solids.

Unit IV: Covalent Bonding **8Hrs**

Lewis structures, formal charge. Valence Bond Theory, directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry), partial ionic character of covalent bonds, bond moment, dipole moment and electronegativity differences. Concept of resonance, resonance energy, resonance structures.

Unit V: Other Types of Bonding **8 Hrs**

Molecular orbital concept of bonding (elementary pictorial approach):sigma and pi-bonds, multiple bonding, MO diagrams of H_2, F_2, O_2, C_2, B_2, CO, NO, HF, and H_2O; bond orders, bond lengths, Walsh Diagram. Coordinate bonding: Lewis acid-base CN^-,adducts (examples), double salts and complex salts.

Hydrogen bonding: effect on the physical properties of compounds of the main group elements.

Metallic bonding: qualitative idea of band theory, conducting, semi conducting and insulating properties with examples from main group elements.

BOOKS RECOMMENDED

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller,T. Overton, J. Rourke, F. Armstrong; OxfordUniversity Press, New York, 2018.

PAPER CODE- CHY-112
Mechanistic aspects of Hydrocarbons
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to
1. make the students understand the core concepts of organic chemistry i.e. resonance, hyperconjugation, inductive effect etc. and their qualitative and quantitative treatment.

2. provide an in-depth knowledge about alkanes, cycloalkanes, alkenes & alkynes and their reactivity.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-112	**Mechanistic aspects of Hydrocarbons**	**The students will be able to –** **CO7:** identify different electronic effects and differentiate their role and impacts in a particular situation. **CO8:** describe the structure, stability and reactivity and mechanistic ability of various hydrocarbons **CO9:** learn and identify many organic reaction mechanisms including free radical substitution, electrophilic and nucleophilic addition. **CO10:** predict the products of different hydrocarbons with different reagents	• Traditional chalk & board method with interactive lectures • Group discussions • Question preparation • Subjective type • Long answer • Short answer • Objective type • Multiple choice questions • One answer/two answer type questions • Assertion and reasoning	The oral and written examination s (Scheduled and surprise tests) •Problem solving exercises • Assignment s • Quiz • Semester End Examinatio n

CONTENTS

Unit I: General treatment of reaction mechanism 12 Hrs
Mechanistic classification: 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: generation and stability (brief idea) ofcarbocations- Classical and nonclassical, carbanions, free radicals, carbenes, nitrenes.

Unit II: Chemistry of Alkanes & Cycloalkanes 8 Hrs
Chemistry of alkanes: Formation of alkanes,chemical reactions with special reference to free radical substitutions: bond dissociation energies, halogenation - relative reactivity and selectivity.
Chemistry of cycloalkanes: Types, methods of synthesis, chemical reactions
Baeyer strain theory, Theory of strainless ring.

Unit III: Chemistry of Alkenes 11 Hrs

Hybridization of carbon, cis-trans isomerism, IUPAC nomenclature, general methods of preparation, physical properties. Structure and bonding in alkenes, methods of synthesis and chemical reactions, Mechanism of E1, E2, E_1cB reactions(a brief idea). Saytzeff and Hoffmann eliminations. Electrophilic additions and their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti hydroxylation (oxidation). Addition of singlet and triplet carbenes, Regioselectivity.

Unit IV: Chemistry of Dienes **8Hrs**

Structure and stability of conjugative and cumulative dienes, resonance and molecular orbital structure of allene and 1,3-butadiene; methods of preparation, addition of hydrogen halides to conjugated dienes – 1,4 v/s 1,2 addition (formation, structure and stability of allylic carbocation and free radicals).An elementary concept of orbital symmetry & it's application to Diels-Alder reaction. Allylic and benzylic bromination.

Unit V: Chemistry of Alkynes **6 Hrs**

Nomenclature, Formation and reactions of alkynes, structure& stability, acidity, electrophilic and nucleophilic additions. Hydration to form carbonyl compounds, alkylation of terminal alkynes, reduction of alkynes –catalytic hydrogenation, dissolving metal reduction.

BOOKS RECOMMENDED:

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York,2008.
- Organic Chemistry; Sixth Edition; G. Marc Loudon, J. Parise; WH Freeman, New York, 2015.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.

PAPER CODE- CHY 113
Different states of matter
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to

1. enable the learner to understand state of matter and interchange of states, intermolecular interaction.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

CHY-113	**Different States of Matter**	**The students will be able to –** **CO11:** calculate different types of velocities (average, root mean square and most probable) for gas molecule **CO12:** derive mathematical expression for different properties of gas, liquid and solid and understand their physical significance **CO13:** explain the behaviour of real and ideal gas. **CO14:** explain structure and application of liquid crystal. **CO15:** apply crystallographic law on simple molecule **CO16:** summarize different method of preparation and properties of sol, gel and emulsion. **CO17:** describe concept of adsorption and derive different adsorption isotherm.	Interactive Lectures • Discussions • Tutorials • Problem solving	The oral and written examinations (Scheduled and surprise tests) •Problem solving exercises • Assignments • Quiz • Semester End Examination,

CONTENTS

Unit I: Kinetic Theory of Gases **10Hrs**

Concept of pressure and temperature. Nature of distribution of velocities in one, two and three dimensions. Maxwell's distribution of speeds. Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Calculation of number of molecules having energy ≥ ε, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

Unit II: Gaseous State **10Hrs**

Collision of gas molecules, collision diameter; collision number and mean free path, frequency of binary collisions (similar and different molecules); wall collision and rate of effusion. Deviation of gases from ideal behaviour; compressibility factor; Andrew's and Amagot's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding states and significance of second virial coefficient. Boyle temperature. Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential, elementary idea).

Unit III: Liquid State and Viscosity of Fluids **10Hrs**

Nature of the liquid state, (short range order and long range disorder). Vapour pressure, surface tension, surface energy, excess pressure, capillary rise and measurement of surface tension. Work of cohesion and adhesion, spreading of liquid over other surface. Vapour pressure over curved surface. Temperature dependence of surface tension. General features of fluid flow (streamline flow and turbulent flow). Reynold number, nature of viscous drag for streamline motion. Newton's equation, viscosity coefficient. Poiseuille's equation (with derivation), temperature dependence of viscosity, principle of determination of viscosity coefficient of liquids by falling sphere method. Viscosity of gases vs. liquids and kinetic theory of gas viscosity.

Unit IV: Solid State **8Hrs**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, seven crystal systems and fourteen Bravias lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

Unit V: Colloidal State and Surface Chemistry 7Hrs

Definition and classification. Solids in liquids (sols): properties- kinetics, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.
Liquid in liquids (Emulsions): Types, preparation, and emulsifier.
Liquids in solids (Gels): classification, preparation and properties, inhibition; general application of colloids.
Surface chemistry: Sorption at surfaces, physical and chemical adsorption; Freundlich, Langmuir and Gibbs adsorption isotherms; Factors effecting adsorption, applications of adsorption.

BOOKS RECOMMENDED

- A TextBook of Physical Chemistry; Second edition; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.
- University General Chemistry; C.N.R. Rao; Laxmi Publications., New Delhi, 2015.
- Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Second Edition;New Age International Pvt. Ltd, New Delhi, 2001.
- *Physical Chemistry*; Thirdedition*; Gilbert W. Castellan*; Addison Wesley *Publishing* Company, USA, 1983.
- *Physical Chemistry;* Third edition;*Gilbert W. Castellan*; Narosa, 2004.

PAPER CODE- CHY 114
Mathematical concepts- I
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. enable the students to learn about mathematical concepts which will be helpful in chemical derivations.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

CHY-114	**Mathematical concepts I**	**The students will be able to –** **CO18**: find maxima and minima, critical point and inflection points of functions. **CO19**: produce and interpret graphs of basic function like linear and sparabola. **CO20**: explain and apply basic concepts of probability. **CO21**: solve applied problem of chemistry using differentiation and integration. **CO22**: find roots of equations using numerical method like Newton - Raphson method, binary bisection method. **CO23**: apply numerical method of integration like Trapezoidal and Simpsons rule for integration.	• Interactive Lectures • Discussions • Tutorials • Problem solving	The oral and written examinations (Scheduled and surprise tests) •Problem solving exercises • Assignments • Quiz •Semester End Examination

CONTENTS

Unit I: Recapitulation **9 Hrs**

Fundamentals: Mathematical functions, odd and even functions, Trigonometric functions, polynomial expressions, logarithmic functions, exponential functions, constants and variables, standard forms of straight lines and parabolic equations with graphs.

Unit II: Differential Calculus **9 Hrs**

Differentiation of simple functions like x^n, e^x, logx, higher order derivatives, partial differentiation of first and second order, total differentiation. Maxima and minima of one variable function.

Unit III: Integral Calculus **10 Hrs**

Indefinite integrals, integration of standard function, methods of integration: integration by substitution, integration by parts, integration by means of a partial fraction, definite integrals and their properties.

Unit IV: Numerical Calculus **10 Hrs**

Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary –bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions), numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

Unit V: Mathematical Series and Statistics **7 Hrs**

Power series, Maclaurin, Taylor series, basic concepts of probability distributions (gas kinetic theory) and meanvalues; Binomial (gas kinetic theory)

Note: Calculations involving use of calculator is to be avoided

BOOKS RECOMMENDED

- Mathematics for Physical Chemistry; Second Edition; Mc Quarrie, D. A.; University Science Books,2008.
- Mathematics for Physical Chemistry; Mortimer, R..Fourth Edition. Elsevier, USA 2013.
- The Chemical Maths Book; Second Edition Steiner, E. Oxford University Press, New York, 2011.
- Chemical Calculations; Mathematics for Chemistry; Second Edition. Yates, P. CRC Press 2007.

PAPER CODE- CHY 115
Lab Course I
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. acquaint the students with various safety measures including handling of chemicals, safe disposal of chemical wastes etc.
2. make students understand the concept of separation of mixtures containing metal ions and interfering ions

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
CHY-115	Laboratory Course I	**The students will be able to –** **CO 24:** apply the knowledge of lab safety measures during the experimental work. **CO 25:** analyze and detect various cations and anions in the presence of each other in a given mixture qualitatively. **CO 26:** detect the cations in the presence of interfering radicals.	• Class lectures • Discussions • Demonstrations • Substantial laboratory based practical component and experiments	Written test • Viva-voce • Quiz • Semester end examination

CONTENTS

Laboratory Safety **4 Hrs**

Handling of hazardous chemicals, incompatible chemicals, flammable solvents, fire hazards in chemical laboratory, control of fire, fire extinguishers, toxicity of chemicals, forms of toxic materials, personal protective equipments, health effects and first aid, MSDS (Material Safety Data Sheet), use of compressed gases, waste minimization strategies and chemical waste disposal, procedures for neutralization of strong acids and strong bases.

Inorganic Chemistry **56 Hrs**

Semi- micro Analysis- separation and identification of six ions, cation analysis from Groups I, II, III, IV, V and VI. anion analysis including interfering radicals.

BOOKS RECOMMENDED

- Semimicro Qualitative analysis; J.P.Tandon, Lal Manohar , R.K.Bansal ; University ofRajasthan,Jaipur,1979.
- Vogel's Qualitative Inorganic Analysis; Seventh Edition;G. Svelha, B. Sivasankar; Pearson Education India,2012

PAPER CODE- CHY-116
Lab Course II
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. acquaint the students with different types of volumetric titrations.
2. provide knowledge of viscosity method and surface tension method to determine composition of mixtures.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-116	**Laboratory Course II**	The students will be able to: **CO27**: estimate the concentrations of various compounds volumetrically. **CO28**: apply viscosity method and surface tension method to determine percentage composition.	Class lecture • Discussion • Demonstration • Substantial laboratory based practical component and experiments	• Written Test • Viva Voce Semester End Exams

CONTENTS

A) Inorganic Chemistry

a) Calibration of fractional weights, pipettes and burettes. Preparation of standard solutions. Dilution 0.1 M to 0.001 M solutions, concept of Molarity and Normality

b) Volumetric Analysis

Acid-Base Titration

1.To determine volumetrically the equivalent weight and basicity of the given acid.

2. To determine volumetrically the number of molecules of water of crystallization in washing soda.

3. To estimate volumetrically the strength of Na_2CO_3 and $NaHCO_3$ present in a solution with 0.1 N HCl

4.To determine volumetrically the strength of hydrochloric acid by using standard alkali.

Redox Titration

5. To estimate volumetrically the strength of given FAS solution by using standard solution of $KMnO_4$

6.To determine the strength of given solution of by using standard solution of $KMnO_4$ using a standard solution of sodium oxalate.

(B) Physical Chemistry

1.To determine the percentage composition of a given mixture (non interacting systems) by surface tension method

2. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.

3. To determine the viscosity of amyl alcohol in water at different concentrations and calculate the excess viscosity of these solutions.

4. To determine the viscosity and kinemic viscosity of given oil (Mustard oil) by Redwood viscometer No.1.

5.To determine the relative viscosity of given liquid by Ostwald viscometer.

BOOKS RECOMMENDED

- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Advanced Practical Inorganic Chemistry; Twenty Third Edition; Gurdeep Raj ,Goel Publishing House ,Meerut 2013.
- University Practical Chemistry; Second Edition;P.C.Kamboj, Vishal Publishing House,New Delhi; 2019.
- Practical Engineering Chemistry, Joshi,Sharma,Jain,Kriplani;Ramesh Book Depot,New Delhi 2008.

PAPER CODE- CHY 211
Inorganic Chemistry II
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. acquaint the students with physical and chemical properties of s and p block elements.
2. make students learn the concepts of various diagrammatic presentations i.e. Latimer, Frost, Pourbaix and Ellingham diagrams of potential data along with metallurgy and volumetric analysis.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-211	**Inorganic Chemistry II**	**The students will be able to:** **CO29**: describe the general characteristics of the alkali and alkaline earth metals and also explain the flame colour and spectra of these metals and their compounds **CO 30**: utilize half-reactions to calculate cell potentials and determine spontaneity of reactions and nernst equation to determine effects of concentrations on cell potentials **CO 31**: distinguish between equivalence and end point and carry out redox titration, complexometric titrations. acid base titrations, experiments and associated calculations **CO 32**: identify some common acid-base and metal ion indicators and be able to specify which ones to use for various titrations **CO 33**: draw structures of various xenon compounds and relate behavior of halogens and noble gases	Class lectures • Tutorials • Group discussions • Peer teaching and learning • Question preparation 1. Subjective type ▪ Long answer ▪ Short answer 2. Objective type ▪ Multiple choice questions ▪ One answer/two answer type questions • Assertion and reasoning	• Class test • Semester end examinations ons, Quiz, • Solving problems in tutorials • Assignments • Presentations on

CONTENTS

Unit I: Chemistry of *s*-block Elements **8 Hrs**

Introduction, electronic configuration, diagonal relationships, comparative study of properties of alkali and alkaline earth metals : size of atoms and ions, density, ionization energy, electronegativity, MP & BP, flame colour and spectra, solutions in liquid ammonia, salient features of hydrides and their classification (ionic, covalent and interstitial), solvation and complexation tendencies, Crown ethers and cryptands, biological importance, , anamolousbehaviour of Li and Be, basic Beryllium acetate and nitrate.

Unit II: Chemistry of *p*-block Elements **13 Hrs**

Periodicity in properties of p-block elements with special reference to electronic configuration, atomic and ionic radii, ionization energies, electron-affinity, electronegativity, allotropy, inert pair effect, catenation including diagonal relationship.

Structure and bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, boronhydrides (diborane)and borazinecarboranes,carbidesand its classification, fluorocarbons and graphitic compounds, silicatesand silanes, structural aspects of oxides and oxy acids of phosphorus,nitrogen and sulphur, fullerenes.

Unit III: Halogens and Noble Gases **8Hrs**

General properties of halogens like atomic radius, density, electronegativity, ionization energy, nonmetallic character, color, electron affinity, oxidation states, oxidizing power and reactivity. Unique position of Fluorine, basic nature of halogen, preparation and properties of interhalogen compounds, polyhalides, pseudohalogens.

Noble gases- introduction,isolation, chemical properties of noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Unit IV: Oxidation and Reduction **7Hrs**

Reduction potentials – redox half reactions, concept of over potential; diagrammatic presentation of potential data (Latimer, Frost and Pourbaix diagrams); redox stability in water, disproportionation, oxidation by atmospheric oxygen; elements extracted by reduction – Ellingham diagrams.

Unit V: Basic Principles of Volumetric Analysis **9Hrs**

Simple theoretical background of following types of titrations:

Acid base titrations: Basic principles and its applications

Iodometric &iodimetric titrations: Basic principle, application in standardization ofiodineby $CuSO_4$-hypo and H_3AsO_3.

Redox titrations : Standard potential, SHE, electrochemical series, emf calculations, internal & external indicators, applications in $K_2Cr_2O_7$ oxidation reaction.

Complexometric titrations: Types of EDTA titrations, masking and de-masking agents, metal ion indicator, application in estimation of total hardness.

Precipitation titrations: Basic principle, application in Volhard's method.

BOOKS RECOMMENDED

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.

PAPER CODE- CHY 212
Mechanism of organic reactions and stereochemistry
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. make the students understand the core concepts of organic chemistry i.e. resonance, hyperconjugation, inductive effect etc. and their qualitative and quantitative treatment.
2. provide an in-depth knowledge about the organic-chemical reactions with a focus on aromaticity, stereochemistry, reactive intermediates and their rearrangements

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-212	**Mechanism of Organic Reactions and Stereochemistry**	**The students will be able to –** **CO34**: identify the different aromatic, nonaromatic, homoaromatic & antiaromatic compounds and interpret their properties. **CO35**: evaluate the stability of various acyclic and cyclic systems using steric, electronic and stereoelectronic effects and correlate them to reactivity. **CO36**: describe various types of reactive intermediates and factors affecting their stability. C**O37**: explain the different nature and behavior of organic compounds based on fundamental concepts learnt. **CO38**: formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved. **CO39**: learn and identify many organic reaction mechanisms including free radical substitution,electrophilic addition and electrophilic aromatic substitution. **CO40**:acquaint themselves with the fundamental concepts of stereochemistry.	Class lectures • Tutorials • Group discussions • Use of models • Question preparation 1. Subjective type ▪ Long answer ▪ Short answer 2. Objective type ▪ Multiple choice questions ▪ One answer/two answer type questions • Assertion and reasoning	The oral and written examinations (Scheduled and surprise tests) • Problem solving exercises • Assignments • Quiz • Semester End Examination

CONTENTS

Unit I: Aromaticity **8 Hrs**

Nomenclature of benzene derivatives (mono and disubstituted), physical properties. Introduction to aromatic compounds: Benzene, structure and stability, M.O concept, resonance and resonance energy; Aromaticity, Huckel's rule with cyclic carbocations/carbanions and heterocyclic compounds,annulenes& kekulene as examples,elementary idea of aromatic,antiaromatic and homoaromatic compounds.

Unit II: Aromatic Electrophilic Substitution reactions **8 Hrs**

Aromatic electrophilic substitution – general pattern of the mechanism, σ and π complexes, energy profile diagram,activating and deactivating effects of substituents, orientation,o/p ratio, halogenation, nitration, sulphonation and desulphonation, Friedel-Crafts alkylation and acylation; side chain halogenation of alkyl benzenes (toluene, ethyl benzene), Birch reduction, One carbon electrophiles reactions: chloromethylation, Gatterman-Koch, Gatterman, Hoesch, Vilsmeier-Haack reaction, Reimer-Tiemann, Kolbe-Schmidt.

Unit III: Aliphatic and Aromatic Nucleophilic Substitution **12 Hrs**

General preparation and reactions of alkyl halides, Substitution at sp^3centre - Mechanism: S_N1, S_N2, S_Ni mechanisms with stereochemical aspects, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite) substitution involving NGP

Aryl halides: Preparation, nucleophilic aromatic substitution; Benzyne mechanism, relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Unit IV: Stereochemistry **8 Hrs**

Geometrical isomerism: concept of restricted rotation – cis-trans, syn-anti and E,Z system of nomenclature, geometrical isomerism in oximes, amides and alicyclic compounds. Optical isomerism: elements of symmetry, concept of asymmetry and chirality, enantiomers and diastereomers, racemic mixture and meso isomers; molecular chirality – allenes, relative and absolute configuration, nomenclature of optical isomers – D,L nomenclature, sequence rule and the R,S system of nomenclature, resolution of enantiomers; elementary concepts of asymmetric synthesis (concept of diastereomeric induction).Elementary concept of chiral induction through chemical reaction (reaction of bromine to alkane and alkenes)

Unit V: Conformational Isomerism: Concept of Free Rotation **9 hrs**

Newman, Fischer, Sawhorse and Flying-wedge formula; conformation of ethane, n-butane and cyclohexane **–** axial and equatorial bonds, conformational analysis of monosubstituted and disubstituted cyclohexane (dimethylcylcohexane), concepts of conformational locking; chair conformation of α and β glucose and their stability.

BOOKS RECOMMENDED:

- Stereochemistry: Conformation and Mechanism; Eighth Edition; P.S. Kalsi; New Age International Publishers Pvt Ltd, New Delhi, 2015.
- Reaction Mechanism in Organic Chemistry; Third Edition; S.M. Mukherjee and S.P. Singh; Laxmi Publications, New Delhi, 2007.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010

PAPER CODE- CHY 213
Thermodynamics
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. make the students learn various laws of thermodynamics and their applications. 2. learn about thermodynamic functions and thermodynamic conditions for equilibrium. 3. make students aware about thermodynamic conditions for equilibrium and the concept of solubility and common ion effect.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-213	**Thermodynamics**	**The students will be able to –** **CO41:** describe the concept of thermal equilibrium and Zeroth-law of thermodynamics. **CO42:** state and apply the first law of thermodynamics for COsed and open systems undergoing different thermodynamic processes to calculate change in internal energy. **CO43:** describe Hess's law of constant heat summation and Kirchoff's relations and can apply them. **CO44:** describe the need of second law of thermodynamics and know various thermodynamic relations. **CO45:** understand the concept of thermodynamic state functions and their variation with temperature and pressure. **CO46:** apply various laws of chemical equilibrium and know the concept of common ion effect.	Interactive Lectures ▪ Discussions ▪ Tutorials ▪ Problem solving	Presentati ons by individua l student/ group of three Students • Class Tests at Periodic intervals. • Written assignme nt(s) • Semester End Examinat ion

CONTENTS

Unit I: First Law of Thermodynamics **12Hrs**

Importance and scope, definitions of system and surroundings; type of systems (isolated, closed and open). Extensive and intensive properties. Steady state and equilibrium state. Concept of thermal equilibrium and the zeroth-law of thermodynamics. Thermodynamic coordinates, state of a system, equation of state, state functions and path functions. Partial derivatives and cyclic rule. Concept of heat and work (IUPAC convention). Graphical explanation of work done during expansion and compression of an ideal gas. Reversible and irreversible processes and work done. First law of

thermodynamics, internal energy (U) as a state function. Enthalpy as a state function. Heat changes at constant volume and constant pressure; relation between C_P and C_V using ideal gas and vander Waals equations. Joule's experiment and its consequence. Explanation of term $(\delta U/\delta V)T$. Isothermal and adiabatic processes. Joule-Thomson experiment and its consequences; inversion temperature. Joule-Thomson coefficient for a van der Waals gas, General heat capacity relations.

Unit II:Thermochemistry **6 Hrs**

Thermochemistry: heat changes during physicochemical processes at constant pressure/volume. Hess's law of constant heat summation and applications, Kirchoff's relations. Bond dissociation energies. Changes of thermodynamic properties in different chemical changes

Unit III: Second Law of Thermodynamics **10 Hrs**

Second law of thermodynamics – need for a Second law. Concept of heat reservoirs and heat engines. Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation. Carnot cycle and refrigerator. Carnot's theorem; thermodynamic scale of temperature.
Physical concept of entropy. Entropy as a measure of the microscopic but not macroscopic disorder. Entropy change of systems and surroundings for various processes and transformations. Entropy change during the isothermal mixing of ideal gases. Nernst Heat Theorem, Third law of thermodynamics (elementary idea) Entropy and unavailable work. Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium.
Thermodynamic relations: Maxwell's relations, thermodynamic equation of state, Gibbs- Helmholtz equation.

Unit IV : Thermodynamic Functions **7 Hrs**

Open system, chemical potential and activity, partial molar quantities, chemical potential in terms of Gibb's free energy and other thermodynamic state functions and its variation with temperature and pressure. Gibbs-Duhem equation; fugacity of gases and fugacity coefficient.

Unit V Chemical Equilibrium **12 Hrs**

Thermodynamic conditions for equilibrium, degree of advancement. Van't Hoff's reaction isotherm (deduction from chemical potential). Explanation of the free energy versus degree of advancement plot. Equilibrium constant and standard Gibbs free energy change. Definitions of K_P, K_C and K_x ; van't Hoff's reaction isobar and isochore from different standard states. Shifting of equilibrium due to change in external parameters e.g. temperature and pressure. Le Chatelier's principle and degree of advancement. Activity and activity coefficients of electrolyte / ion in solution. Debye-Huckel limiting law (statement and applications only). Solubility equilibrium and common ion effect

BOOKS RECOMMENDED:

- A Textbook of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.

- Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Second Edition;New Age International Pvt. Ltd, New Delhi, 2001.
- Physical Chemistry; Sixth Edition ; G.M. Barrow; McGraw Hill, New Delhi, 1996.

PAPER CODE- CHY 214(a)
Mathematical Concepts - II
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. make the student aware about the concept of matrix, determinant, vectors, differential equation, complex numbers, differential and integral calculus and their use in some important applications of chemistry

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-214 (a)	**Mathematical Concepts - II**	**The students will be able to –** **CO47:** apply basic operations of matrices to solve simultaneous equations. **CO48**: use basic operations of vectors, vector derivatives and coordinate systems. **CO49**: apply the basic differential and integral calculus to determine extreme and stationary points of a function. **CO50**: solve first order and first degree linear differential equation. **CO51**: apply the concept of complex numbers in solving the related problems.	Approach in teaching: ▪ Interactive Lectures, ▪ Explicit Teaching ▪ Discussion ▪ Didactic questions, Tutorials ▪ Multimedia Presentations ▪ Demonstration • Learning activities for the students: ▪ Self learning Assignments, Peer Assessment, Concept mapping, ▪ Think/Pair/Share, Problem Solving, Power Point Presentation, Handouts	• The oral and written examinations (Scheduled and surprise tests) • Closed book and open book tests • Quiz • Problem solving exercises • Assignments • Presentation Semester End Examinations

CONTENTS

Unit I: Matrices and Determinants **9 Hrs**

Matrix algebra, Determinants, matrix inversion, Solving Simultaneous equations using inverse of a matrix, consistency and independence. Simultaneous equations with three unknowns (e.g. spectrophotometry) using Cramer's rule. Homogeneous linear equations.

Unit II : Vectors **9 Hrs**

Vectors and coordinate systems: Unit vectors (application in solid state), Component of vectors, addition and subtraction of vectors, multiplication of vectors. Vector calculus: differentiation of vectors, Vector derivative operators(Basic concepts of gradient, divergence and curl).Coordinate systems in three dimensions (Cartesian, polar, spherical and their interconversion).

Unit III : Application of differential and integral calculus **9 Hrs**

Maximum and minimum values of functions of two variables. Extreme points and stationary points of a function, Euler's theorem on homogenous function of two variable. Multiple integrals (Basic concepts of double and triple integral).Changeof order of double integration.

Unit IV : Differential Equations **9 Hrs**

Differential equations: Order and degree of differential equations, solution of first order and first degreedifferential equations with separable variables, homogeneous and linear differential equations, partial differential equation of first order PDE, types of integrals of a PDE, the integral of the Lagranje's linear equation, solution of first order PDE using Charpit's method.

Unit V: Complex Numbers **9 Hrs**

Complex numbers, complex plane, Argand diagram,complex conjugates, modulus of a complex number, square root of a complex number, Euler's formula and polar form of complex numbers.

BOOKS RECOMMENDED

- Mathematics for Physical Chemistry; Second Edition; McQuarrie, D. A.; University Science Books, 2008.
- Mathematics for Physical Chemistry; Mortimer, R.. Fourth Edition. Elsevier, USA 2013.
- The Chemical Maths Book; Second Edition Steiner, E. Oxford University Press, New York, 2011.
- Chemical Calculations; Mathematics for Chemistry; Second Edition. Yates, P. CRC Press 2007.

PAPER CODE- CHY 214 (b)
Biology for Chemists
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. make the students understand the disciplinary knowledge, structure and function of biological molecules.

2. enable the students to acquire knowledge of structure and function of fats, phospholipids, proteins and nucleic acids.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 214 (b)	**Biology for Chemists**	**The students will be able to –** **CO52:** develop the understanding of structure and function of some simple cell organelles **CO53:** describe the properties of nucleotides and explain the different composition and roles of nucleic acids in the cell **CO54:** distinguish between monosaccharides, disaccharides, and polysaccharides and also identify several major functions of carbohydrates **CO55:** discuss the different levels of protein structure and analyze determine structure in polypeptides **CO56:** interpret the general properties of the fatty acids and properties of the chains found in lipid membranes in phospholipids	Interactive lectures • Group discussions • Peer teaching and learning • Question preparation Subjective type- ▪ Long answer &Short answer o Objective type- ▪ Multiple choice questions, ▪ One answer/two answer type questions & Assertion and reasoning	Class test • Quiz • Solving problems in tutorials • Assignments • Presentation • Semester end examinations

CONTENTS

Unit- I: The Matrix of Life **9 Hrs**

Origin of Life: elementary idea of prokaryotic and eukaryotic cell, difference between plant and animal cell, cell organelles and their functions: plasma membrane, chloroplast, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, ribosomes, nucleus.

Unit-II: Nucleic Acids **9 Hrs**

DNA- Double helical structure of DNA, types of DNA -A, B, C and Z forms, replication.
RNA- RNA structure and its types- r RNA, mRNA, and tRNA

Unit-III: Proteins. **9 Hrs**

Amino acids: Structure of amino acid, Types of amino acid (essential and nonessential), structure of zwitterions, Peptide Bond. Structure of proteins: primary, secondary-α helix and β pleated sheets, tertiary and quaternary structure.

Unit -IV: Carbohydrates **9 Hrs**

Classification, structure and functions of monosaccharides, disaccharides, polysaccharides - starch, cellulose, glycogen, chitin and pectin. Glycoconjugates: proteoglycans, glycoproteins and glycolipids

Unit -V: Lipids **9 Hrs**

Structure and functions of lipids, Saturated and Unsaturated fatty acid, classification- Simple compound and derived lipids (steroids and cholesterol), Synthesis of long chain fatty acids**,** α**-**oxidation andβ-oxidation.

BOOKS RECOMMENDED

- Lehninger Principles of Biochemistry; Seventh Edition; David L. Nelson, Michael M. Cox; W H Freeman, 2017.
- Biochemistry; Ninth Edition; Jeremy M. Berg , LubertStryer , John Tymoczko , Gregory Gatto ;WH Freeman, 2019.
- Biochemistry; First Indian Reprint;J. David Rawn, Panima Publishing Corporation, New Delhi, 2004.
- Biochemistry; Fourth Edition; Voet and Voet; John Wiley and Sons Inc., New York, 2010.
- Outline of Biochemistry; Fifth Edition; E.E. Conn and P.K. Stumpf; Wiley India Pvt Ltd., New Delhi, 2006.

PAPER CODE- CHY 215

Lab Course III
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. equip the students with practical skills to carry out quantitative analysis involving volumetric estimations.
2. extend the concepts of thermochemistry in calculating the thermodynamic factors for different systems using suitable techniques

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
CHY-215	**Laboratory Course III**	**The students will be able to –** **CO 57**: demonstrate their acquired skills to set up and perform different types of titrations accurately **CO58:** differentiate between various types of titrations by applying the practical knowledge **CO59**: distingish between different combinations of acid and base based on their strengths and neutralization enthalpies **CO60:** sketch the variance of solubility of benzoic acid in water with different temperatures	Interactive Lectures • Discussions • Tutorials • Substantial laboratory based practical component and experiments	Continuous assessment via written test • Demonst rations • Semester End Exam (Practical as well as written test) followed by Vivavoce

CONTENTS

Inorganic Chemistry **44 Hrs**

(A) Quantitative Analysis.

Volumetric Analysis

(i) Determination of acetic acid in commercial vinegar using NaOH.

(ii) Determination of alkali content-antacid tablet using HCI.

(iii) Estimation of calcium content in chalk as calcium oxalate by permanganometry.

(iv) Estimation of hardness of water by EDTA (Temporary and Permanent).

(v) Estimation of ferrous and ferric dichromate method.

(vi) Estimation of copper using thiosulphate.

(vii) Determination of the strength of FAS by titrating with $K_2Cr_2O_7$ using external indicator (potassium ferricyanide)

Physical Chemistry **16 Hrs**

Thermochemistry

1. To determine the enthalpy of neutralisation of strong acid and strong base.
2. To determine the enthalpy of neutralization a weak acid/weak base versus strong base/strong
   acid and determine the enthalpy of ionization of weak acid/weak base.
3. Determination of enthalpy of hydration of copper sulfate.
4. Study of solubility of benzoic acid in water at different temperatures and determination of Δ H.

BOOKS RECOMMENDED

- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Advanced Practical Inorganic Chemistry; Twenty Third Edition; Gurdeep Raj ,Goel Publishing House ,Meerut 2013.

PAPER CODE- CHY 216
Lab Course IV
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:
This course will enable the students to -

1. enable the students to perform simple qualitative tests to identify unknown organic compounds
2. parallelly enhance their grasp on the quantitative estimations under the domain of organic chemistry.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY216	**Laboratory Course IV**	**The students will be able to –** **CO61**: document the results of the preliminary examination of the organic compound by virtue of visual and olfactory tests **CO62:** perform step-wise qualitative tests to identify simple organic compounds **CO63:** calculate the neutralization equivalent of an acid **CO64:** estimate carbohydrates and fats quantitatively	Interactive Lectures • Discussions • Tutorials • Substantial laboratory based practical component and experiments	• Continuous assessment via written test • Demonstrations • Semester End Exam (Practical as well as written test) followed by viva-voce

CONTENTS

Organic Chemistry:

Qualitative Analysis

Identification of an organic compound (solid and liquid) through the element detection, functional group analysis, determination of melting point/ boiling point and preparation of suitable derivatives.

Quantitative Analysis

(a) To determine the neutralization equivalent of the acid.
(b) Estimation of glucose by Fehling's solution/Benedict's solution method
(c) Estimation of saponification value of oil.

BOOKS RECOMMENDED

- Organic Analytical Chemistry: Theory and Practice; JagMohan , Narosa Publishing House, New Delhi, 2014.

PAPER CODE- CHY-311
Inorganic Chemistry III
(Theory)

Credits: 3
Maximum marks: 100

Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. explain the trends in properties and reactivity of d-block elements and enable to acquaint with the basic concepts of coordination chemistry
2. predict relative strengths of acids and bases along with Lewis acid/base behaviour for compounds.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
CHY-311	**Inorganic Chemistry III**	**The students will be able to –** **CO65**: discuss the properties d block elements like magnetic, spectral property and stability of variable oxidation of transition elements **CO66**: compare and analyze the properties of first transition series (3d) with the second transition series (4d) and third transition series(5d) **CO67**: describe the fundamentals of coordination chemistry of metal ions **CO68**: identify and distinguish between different types of isomerism in coordination complexes and predict the spectroscopic and magnetic properties of f-block elements	Interactive lectures • Group discussion • Peer teaching and learning • Question preparation o Subjective type- ▪Long answer & Short answer o Objective type- ▪Multiple choice questions, ▪One answer/two answer type questions • Assertion and reasoning	Class test • Semester end examinations • Quiz • Solving problems in tutorials • Assignment s • Presentation

CONTENTS

Unit I: Chemistry of d-block Elements **11Hrs**

Pre requisite: An elaborate idea of periodic table and electronic configurations

Introduction, electronic configuration, characteristic properties of d-block elements (I, II & III transition series)– ionic and atomic radii, metallic character, variable oxidation states and their stability, density, melting point and boiling point., catalytic properties, ionization energies, magnetic properties and its origin, measurement of magnetic moments, colour, complexation tendencies, comparison of the elements of first transition series with second and third transition serieswith special reference to magnetic property, spectral property,metal-metal bonding and cluster compounds (elementary approach)

Unit II :Chemistry of *f*-blockElements **10Hrs**

Lanthanides: definition, position of lanthanides in the periodic table, separation of rare earth elements (solvent extraction and ion exchange method only), electronic configuration,

physical properties, oxidation states, atomic and ionic radii, lanthanide contraction, causes and consequences of lanthanide contraction, magnetic and spectral properties; comparison between d- and f- block elements.

Actinides: definition, position of actinides in the periodic table, electronic configuration, separation of actinides, general characteristics of actinides and their comparison with lanthanides with special reference to magnetic properties, spectral properties and oxidation states, complexation tendency.

Unit III:Concepts of Coordination Chemistry 10Hrs

Definition of coordination compounds, history ofcoordination compounds, Werner's coordination theory, concept of effective atomic number (EAN concept), classification of ligands, chelation, polynuclear complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds, structural isomerism and its types, stereochemistry of complexes of 4 and 6 coordination number, valence bond theory applied on octahedral, tetrahedral and square planar complexes, Salient features of Valence Bond Theory(VBT),structure of Octahedral, tetrahedral and square planar complexes on the basis of VBT and its limitations

Unit IV : Acids and Bases 7Hrs

Arrhenius concept, Bronsted-Lowry theory, general theory of solvent system, Lux-Floodconcept, Lewis acid-base and its applications, concept of HSAB principle, HSAB: Characteristics of hard and soft acids and bases, symbiosis in hardening/softening, acid base strength, theories (Ionic and Covalent bonding and π bonding theory) of HSAB and its applications.

Unit V: Non-aqueous Solvents 7Hrs

Classification of solvents, physical properties of ionising solvents, water as universal solvent, liquid ammonia, liquid sulphur dioxide, liquid HF and BrF_3as solvent.

BOOKS RECOMMENDED

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Nomenclature of Inorganic Chemistry – Recommendations – 1990; Edited by G.J. Leigh; Jain Interscience Press, Delhi, 1994.
- Inorganic Chemistry; Fifth Edition ; A. G. Sharpe, C.E. Housecraft; Pearson Education,England, 2018
- Advanced Inorganic Chemistry, Sixth Edition; F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann; John Wileyand Sons, USA, New York, 2007.
- General and Inorganic Chemistry Part I & II; Third Edition, R. Sarkar, New Central Book Agency Ltd, 2011.

PAPER CODE- CHY 312
Oxygen containing functional groups
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3

Total Hrs: 45

Course Objectives:

This course will enable the students to –

1.make the students learn how different compounds are prepared by the reactions of carbonyl moiety.
2. introduce how there activity can be explained to allow the introduction of functional group next to carbonyl group.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 312	**Oxygen Containing Functional Groups**	**The students will be able to –** **CO69:** explain the methods of formation and reactivities of various type of aliphatic alcohols (monohydric, dihydric and trihydric) and phenols (understand and comprehension) **CO70:** outline the methods of formation and reactivities of ethers and epoxides (understand and comprehension) **CO71:** predict the relative reactivity of different carbonyl compounds (saturated and unsaturated aldehydes and ketones) and their methods of formation (understand) **CO72:**outline the nucleophilic addition reaction mechanism for carbonyl compounds and predict the product in some name reactions (understand and apply) **CO73:** understand the acidity and reactivity of active methylene groups (understand and apply) **CO74:** outline the synthesis of carboxylic acids and its derivatives from different substrates and analyze the factors of the relative acidities of aliphatic and aromatic carboxylic acids by considering the inductive, resonance and steric effects on the neutral (conjugate acid) form and the anionic (conjugate base) form and compare with alcohols and phenols	Interact ive Lecture s • Group discussi ons • Tutorials • Quiz • Proble m solving session s	• Multiple choice questions • Assertions and reasoning • Short answer questions • Long answer questions • Assignment s • Quiz

CONTENTS

Unit I: Monohydric Alcohols **11 Hrs**

Introduction, classification**,** methods of formation by reduction of aldehydes, ketones, carboxylic acid and esters, biological oxidation of ethanol, hydrogen bonding, acidic nature comparison with thiols, effect of solvents and polarity, reactions of alcohols

Dihydric and Trihydric Alcohols
Method of preparation**,** chemical reactions of vicinal glycols, oxidative cleavage with [$Pb(OAc)_4$] and HIO_4; Pinacol- pinacolone rearrangement.
Trihydric alcohols: introduction, method of preparation and chemical reactions of glycerol

Unit II : Phenols , Ethers and Epoxides 7 Hrs
Phenols: Methods of Preparation, Acidity and factors affecting it, comparative acidic strength of alcohol and phenol, chemical reactions including important name reactions.
Ethers and Epoxides: Preparation and reactions

Unit III: Carbonyl Compounds-I 8 Hrs

Synthesis from acid chlorides, 1,3-dithianes and enamines, nitriles and carboxylic acids; mechanism of nucleophilic addition reaction to carbonyl group with particular emphasis on Benzoin, Perkin, aldol, Knoevena gel condensations, Reformatsky reaction and Dieckman condensation, condensation with ammonia & its derivatives including reactions with primary & secondary amines, Mannich & Wittig reactions.

Unit IV: Carbonyl Compounds-II 10Hrs

Oxidation and reduction rections of Aldehydes and ketones :

Use of acetals as protecting groups, oxidation of aldehydes, Baeyer- Villiger oxidation of ketones, Oppenauer oxidation. ,Cannizzaro reaction, MPV,Clemmensen,Wolff-Kishner,$LiAlH_4$,$NaBH_4$ reductions, α,β- unsaturated carbonyl compounds(cyclic & acyclic) , conjugate addition of enolates & amines, , keto-enol tautomerism of ethylacetoacetate, evidences in favour of keto-enol tautomerism, Claisen condensation, alkylation of diethyl malonate & ethyl acetoacetate,

Unit V: Carboxylic Acids and their Derivatives 9 Hrs

Preparation, physical properties, acidity and reactions of monocarboxylic acids:
Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/pthalic, lactic, tartaric, citric, maleic and fumaric acids.
Preparation and reactions of acid chlorides, anhydrides, esters and amides; comparative study of nucleophilic sustitution at acyl group - mechanism of acidic and alkaline hydrolysis of esters.

BOOKS RECOMMENDED

- Organic Chemistry; Fourth Edition, Indian Edition; G. Marc Loudon; Oxford University Press, New York, 2008.
- Organic Chemistry; Sixth Edition; G. Marc Loudon, J. Parise; WH Freeman, New York, 2015.
- Organic Chemistry; Twelfth Edition; T.W. Graham Solomons, Craig B. Fryhle, S.A. Syndes; John Wiley and Sons, Inc. USA, 2016.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.
- Organic Chemistry; Second Edition; Jonathan Clayden, Nick Greeves and Stuart Warren; Oxford University Press, USA, 2014.
- Organic Chemistry Vol. I ; Sixth Edition; I.L. Finar; Pearson Education, New Delhi2002.

PAPER CODE- CHY 313
Solutions and Phase Rule
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. make the students understand the concepts of ionic equilibria, solutions and application of thermodynamics to heterogeneous equilibria.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-313	**Solutions and Phase Rule**	**The students will be able to –** **CO75**: explain various aspects related to ionic equilibrium such as ionization of an electrolyte, salt hydrolysis, buffer solutions, solubility, solubility product, acid-base indicators. **CO76**: discuss the concepts of the four colligative properties and produce their mathematical relations. **CO77**: describe the dissociation of ionic compounds in solution and the effects on colligative properties (van't Hoff factor, i). **CO78**: compute the concentration of solutions in molarity, mass percent, molality, and mole fraction. **CO79**: analyse the behavior of azeotropes and partially miscible liquids. **CO80**: outline different regions, lines, points in phase diagrams and identify normal boiling point, melting point, critical point and triple point.	**Approach in teaching:** • Interactive Lectures • Explicit Teaching Discussion • Didactic questions Tutorials • Multimedia Presentations, • Demonstration **Learning activities for the students:** • Self-learning Assignments, • Peer Assessment, • Concept mapping, • Think/Pair/Shar e, Problem Solving, Power Point Presentation, Handouts	The oral and written examinations (Scheduled and surprise tests) COsed book and open book tests • Quiz • Problem solving exercises • Assignments • Presentation • Semester End Examinations

CONTENTS

Unit I: Ionic Equilibria **12Hrs**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri- protic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; Buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid – base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants

Unit II: Dilute Solutions– Colligative Properties 9 Hrs

Introduction, colligative properties, Raoult's law, relative lowering of vapour pressure; Osmosis, law of osmotic pressure and its measurement, Elevation of boiling point and its measurement, Depression of freezing point and its measurement, Use of colligative properties in molecular weight determination; Non-ideal behaviourandvan't Hoff's factor 'i'

Unit III: Solutions and Non-ideal Solutions 8 Hrs

Solutions: Ideal and non-ideal solutions, methods of expressing concentrations of solutions, Solution of gases in liquid: Henry's law, deviation from Henry's law. Non ideal system: azeotropes –ethanol-water systems. Partially miscible liquids: phenol-water, trimethylamine-water, nicotine-water systems; lower and upper consolute temperature, effect of impurity on consolute temperature; Immiscible liquids.

Unit IV: Heterogeneous Equilibrium 9 Hrs

Introduction to phase, component and degree of freedom, derivation of Gibbs phase rule;

Phase equilibria of one component system-water, CO_2 and sulphur system, liquid helium.

Phase equilibria of two component system-solid-liquid equilibria, simple eutectic – Bi-Cd, KI-H_2O, Pb-Ag systems, desilverisation of lead.

Unit V: Heterogeneous Equilibria II 7 Hrs

Solid solutions: compound formation with congruent melting point (Mg-Zn) and incongruent melting point (NaCl-H_2O), ($FeCl_3$ – H_2O), ($CuSO_4$ – H_2O)and (Na_2SO_4–H_2O) system; freezing mixtures (acetone – dry ice).

Phase diagrams for three component systems. Acetic acid –chloroform-water

BOOKS RECOMMENDED

- A Textbook of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.
- Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Second Edition;New Age International Pvt. Ltd, New Delhi, 2001.

PAPER CODE- CHY 314
Basic Concepts of Physics
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. develop ability to understand and create rigorous formal mathematical arguments and apply basic mathematical logic.
2. aware the students about various phenomenon of waves and optics.
3. learn about the electronic component like Diode, transistor etc.
4. understand number representation and conversion between different representation in digital electronic circuits

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-314	**Basic concepts of physics**	**The students will be able to –** **CO81:** compute dot product, cross product, length of vectors, gradient functions. **CO82**: apply Fundamental Theorem of Line Integrals, Stokes' Theorem, or Divergence Theorem to evaluate integrals. **CO83**: explain the phenomena of simple harmonic motion and the properties of systems executing such motions. **CO84:** use the principles of wave motion and superposition to explain the Physics of polarisation, interference and diffraction. **CO85:** analyze, design and implement combinational logic circuits. **CO86:** to understand and examine the structure of various number systems and its application in digital design	**Approach in teaching:** ▪ Interactive Lectures ▪ Discussion ▪ Didactic questions ▪ Tutorials ▪ Demonstra tion **Learning activities for the students:** ▪ Self learning As signments ▪ Seminar Presentation ▪ Giving tasks ▪ Simulation ▪ Effective questions	Quiz • Class test • Problem solving exercises • Assignments • Presentations • Participation in class discussions on questions posted prior the lecture • Semester End Examinations

CONTENTS

Unit I: Mathematical Physics and Vector Calculus: 7 Hrs

Scalar and vector fields, Scalar and vector products, differentiation of a vector, gradient, divergence and curl operations and their meaning, Gauss and Stokes' theorem.

Unit II: Mechanics: 11 Hrs

Linearity and superposition principle, free oscillation with one and two degrees of freedom, simple pendulum, combination of two simple harmonic motions. Lissajous figures, free and damped vibrations, forced vibrations and resonance, Q factor, wave equation, travelling and standing waves, superposition of waves, phase and group velocity.

Unit III: Wave Optics 8 Hrs

Interference, Young's double slit interference in thin films. Fresnel and Fraunhofer diffraction: plane transmission grating, resolving power of a telescope and a microscope, resolving and dispersive power of a plane diffraction grating. Polarization: Polarization by reflection and refraction, Brewster's law, quarter and half-wave plates, Production and analysis of circularly and elliptically polarized light.

Unit IV : Electronics 11 Hrs

Half-wave, full-wave and bridge rectifiers, ripple factor, rectification efficiency, filters (series in inductor, shunt capacitator, LC and π sections), voltage regulations, Zener diode as voltage regulator. Construction and working of bipolar junction transistors, Characteristic curves of CE, CB and CC configuration circuits, negative and positive feedback. Barkhausen's criterion for self-sustaining oscillations.

Unit V : Digital Electronics 8Hrs

Number systems (binary), Logic gates, AND, OR, NAND, NOR and XOR. Boolean algebra (Boolean laws and simple expressions), binary adders, half adder, half subtractor, full adder and full subtractor.

BOOKS RECOMMENDED

- Vector Analysis Schaum's Outline Series; Second Edition; M. R Spiegel; McGraw-Hill Book Co., Singapore, 2017.
- Concepts of Modern Physics; Seventh Edition; A. Beiser, S. Mahajan, S.R. Choudhary; McGraw-Hill Education, 2017.
- Physics Vol. I and II Fifth Ed , Resnick, R., Halliday, D. & Krane, K. S., John Wiley &Sons, 2004.
- Physics for Scientists and Engineers Ninth Edition; Serway, R. A. & Jewett, J. W.; Cengage India Pvt Ltd, 2017.
- Introduction to Electromagnetism;Fourth Edition; Griffiths, D. J.; Pearson Education, New Delhi,2015.
- Digital Principles and Applications; Seventh Edition;Malvino, A.P. & Leach, D. P. Tata McGraw-Hill, 2008.
- Electronic Fundamentals and Applications; Fifth Edition.; Ryder, J. D.; Prentice-Hall, Inc.,2007.
- Electronics Fundamentals: Circuits, Devices and Applications, Eighth Ed.; Floyd, T. L. & Buchla, D. M. Pearson New International Edition, 2013.
- Optics; Fifth Edition; Brijlal and Subrahmanyam;S.Chand Publications; New Delhi, 2015.

PAPER CODE- CHY 315
Lab Course V
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. learn about different analytical technique to measure physical property like transition temperature, freezing point depression, lattice energy etc.
2. learn about the method of preparation of inorganic coordination compounds.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY315	**Laboratory course V**	**The students will be able to –** **CO87**: prepare simple coordination compounds. **CO88**: illustrate the concept of adsorption and will be able to plot Freundlich and Langmuirs adsorption isotherm **CO89**: describe Nernst distribution law and calculate partition coefficient. **CO90**: determine critical solution temperature for binary mixture. **CO91**: determine pKa value of acid by using Henderson equation. **CO92**: determine freezing point depression constant	• Interactive Lectures • Discussions • Tutorials • Substantial laboratory-based practical component and experiments.	Quiz • Class test • Problem solving exercises • Assignments • Presentations • Participation in class discussions on questions posted prior the lecture • Semester End Examination s

CONTENTS

Unit I Inorganic synthesis **20 hrs**

a) Preparation of Bis-Dimethylglyoxime-nickel (II)

b) Preparation of Sodiumtrioxalatoferrate (III)

c) Preparation of cis and trans-bisoxalatodiaquachromate (II)

d) Preparation of Prussian blue $Fe_4[Fe(CN)_6]_3$

Physical Chemistry

Minor experiments **40 Hrs**

a) To determine the mutual solubility curve of phenol – water system and their consolute point.

b)To determine the transition temperature of given substance by thermometric method.

c) Determination of freezing point depression constant of camphor using Rast method.

d) Determine the lattice energy of calcium chloride from its heat of solution using Born-Haber cycle. You are provided the Enthalpy changes for Ca^{+2} (g) → Ca(g) $2Cl^-$ (g) → 2Cl (g), Ca (g) → Ca (s), 2Cl (g) → Cl_2 and Ca (s) + Cl (g) → $CaCl_2$ (s) as -451.1, 174.3, -38.8, -58.0 and -190.0 Kcal/mole respectively.

e) To determine the heat of solution of KNO_3 at a specified water-salt mole ratio.

f) To determine pH of different buffer solutions and evaluate pKa of acid by using Henderson equation.

Major experiments

e) To study the effect of a solute (NaCl/succinic acid) on the critical solution temperature of two partially

miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the

system

f) To study the absorption of acetic acid or oxalic acid from aqueous solution by activated charcoal or animal charcoal and examine the validity of Freundlich and Langmuirs adsorption isotherms.

g) Determination of partition coefficient of acetic acid between butanol and water.

h) To study the freezing point curve of two component simple eutectic system (acetamide-benzoic acid/ naphthalene-benzoic acid)

BOOKS RECOMMENDED

- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.
- Advanced Practical Inorganic Chemistry; Twenty Third Edition; Gurdeep Raj,Goel Publishing House,Meerut, 2013.
- College Practical Chemistry; V.K.Ahluwalia, Sunita Dhingra, Adarsh Gulati; UniversitiesPress (India Pvt Ltd), 2005.

PAPER CODE- CHY 316
Lab Course VI
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. enable students to do experiments on the fundamental laws and principles of physics.

2. gain experience of using a variety of measuring instruments. Practical work enhances basic learning skills

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 316	**Laboratory course VI**	**The students will be able to –** **CO93:** develop skills for team work and technical communication and discussions **CO 94:** to gain practical knowledge by applying the experimental methods to correlate with the Physics theory. **CO 95**: to learn the usage of electrical, Oscillations and optical systems for various measurements **CO 96**: apply theoretical principles of Digital electronics to analysis and measurements performed in the laboratory	Interactive Lectures • Discussions • Tutorials • Substantial laboratorybased practical component and experiments	Continuous assessment via written test • Demonstrations • Semester End Exam (Practical as well as written test) followed by Viva-voce

CONTENTS

1. To study damping of a compound pendulum and to determine the quality factor.
2. To determine the wavelength of sodium light by grating.
3. To study of half wave rectifier and to determine its ripple factor.
4. To study input and output characteristics of a transistor in common emitter configuration.
5. To verify truth tables for AND, OR, NAND, NOR, XOR logic gates.
6. To determine Brewster's angle and refractive index of glass by using spectrometer and polaroids

PAPER CODE- CHY 411
Inorganic Chemistry IV
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. provide the in-depth knowledge of the nature of metal-ligand bonding in coordination compounds.
2. understand the magnetic and spectral aspects of transition metal complexes and their applications.
3. acquaint the students with the basic principles of analytical and gravimetric techniques.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-411	**Inorganic Chemistry IV**	**The students will be able to –** **CO97:** distinguish between splitting pattern of orbitals for different geometries of complexes **CO98:** calculate CFSE for different geometries of complexes and identify the cause and infer the consequence of Jahn Teller and list out the applications of CFT **CO99:** differentiate between different types of magnetic behavior and interpret magnetic moments for different complexes **CO100:** describe L-S coupling and compute ground state terms and employ selection rules and sketch orgel diagrams and discuss electronic spectra **CO101**: classify different types of errors distinguish between accuracy and precision and calculate various types of deviations to express precision. **CO102:** discuss principles and methods involved in gravimetric analysis	Class lectures • Tutorials • Group discussions • Peer teaching and learning • Question preparation ▪ Subjective type • Long answer • Short answer ▪ Objective type • Multiple choice questions • One answer/two answer type questions • Assertion and reasoning	The oral and written examinations (Scheduled and surprise tests) ▪ Closed book and open book tests ▪ Problem - solving exercise s ▪ Assignments ▪ Quiz ▪ Semester End Examination

CONTENTS

Unit I: Theory of Bonding in Coordination Compounds : CFT 11 Hrs

Crystal Field Theory: Postulates, splitting of d orbitals in octahedral,tetrahedral, tetragonal and square planar fields, spectrochemical series,factors affecting the magnitude of Δ_0, crystal field stabilization energy in weak and strong fields; pairing energy, number of unpaired electrons and high spin (HS) and low spin (LS) complexes,distribution of d-electrons in t_{2g} and e_g orbitals in octahedral and tetrahedral complexes, distortion of octahedral complexes- Jahn Teller theorem; use of CFSE values, applications and limitations of CFT.

Unit II:Magnetic Properties of Transition Metal Complexes 9Hrs

Types of magnetism, types of magnetic behaviour, orbital and spin magnetic moments, methods of determining magnetic susceptibility by Gouy's balance, spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); applicationsof magnetic moment data for transition complexes.

Unit III: Electronic Spectra of Transition Metal Complexes 10Hrs

Types of electronic transitions; coupling of orbital angular momenta and spin angular momenta (in p^2 and d^2 configuration), spin orbit coupling/LS coupling, determining the ground state terms – Hund's rule, hole formulation, calculation of the number of micro states; selection rules- Laporte 'orbital' selection rule, spin selection rule, spectroscopic ground states; Orgel energy level diagram for d^1 and d^9 states, (one electron – one hole),discussion of electronic spectrum of $[Ti(H_2O)_6]^{+3}$ complex, charge transfer spectra (elementary idea).

Unit IV : Basic Principles of Analytical Techniques 7 hrs

Data Analysis: errors in chemical analysis, classification of errors (determinate indeterminate, systematic and random errors in chemical analysis with examples, absolute and relative errors), accuracy and precision, minimisation of errors; distribution of random errors, normal error curve, significant figures; statistical analysis – mean and standard deviation; relative standard deviation coefficient of variance, sampling in analysis, rejection of results, presentation of data.

Unit V: Gravimetric Methods of Analysis 8 Hrs

Requirements of gravimetry: properties of precipitates and precipitating regents, particle size and filterability of precipitates, colloidal and crystalline precipitates, co-precipitation and post-precipitation,washing, drying and ignition of precipitates, precipitation in homogenous media, principles of gravimetric estimation of chloride, zinc, iron and aluminum singly.

Uses of Reagents in gravimetric analysis: Dimethyl Glyoxime, 8-Hydroxy quinoline, Anthranilic acid, Cupferron.

BOOKS RECOMMENDED

- Concise Inorganic Chemistry; Fifth Edition; J.D. Lee; Wiley India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry (Principle ,Structure and Reactivity); Fourth Edition; J. E Huheey, E. A. Keiter, R. L. Keiter; Pearson India, New Delhi, 2013.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Advanced Inorganic Chemistry, Sixth Edition; F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann; John Wiley and Sons, USA, New York, 2007.
- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.

PAPER CODE- CHY 412
Nitrogen containing functional groups, Natural products and Drugs
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Provide students a clear understanding of environmental concerns and to follow sustainable development practices
2. Analyze concepts and methods from ecological and physical sciences and their application in environmental problem solving

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-412	**Nitrogen containing functional groups, Natural products and Drugs**	**The students will be able to –** **CO103:** describe some of the important methods of preparation and properties of aliphatic and aromatic nitro and amino compounds mechanistically.(comprehensio n) **CO104:** understand about the different dyes, their chemical structure and reactivity. (understand) **CO105:** outline mechanisms for reactions involving heterocycles (five and six membered) as starting materials and propose syntheses of heterocycles from the major classes. (understand and apply) **CO106:** understand the different types of alkaloids, &terpenoids, their chemistry and medicinal importance. (understand and comprehension) **CO107:** understand the structure and medicinal importance of some important antipyretic, analgesics, antibotics, antimalarials and sulpha drugs. (understand and comprehension)	Interactive Lectures • Group discussions • Tutorials • Quiz • Problem solving sessions	Multiple choice questions • Assertions and reasoning • Short answer questions • Long answer questions • Assignments • Quiz

CONTENTS

Unit I: Nitrogen Containing Functional Groups **9Hrs**

Preparation and important reactions of nitro compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Hoffmann bromamide reaction, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid, amines as phase transfer catalyst.

Unit II: Synthetic Dyes **7 Hrs**

Diazonium Salts: Preparation and their synthetic applications.Colour and constitution (electronic concept), classification of dyes, chemistry and synthesis of methyl orange, congo red, malachite green, crystal violet, phenolphthalein, fluorescein, alizarin and indigo.

Unit III: Heterocyclic Compounds **10 Hrs**

Classification and nomenclature, Structure, aromaticity in 5-membered and 6-membered rings

containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole, Thiophene, Pyridine, Pyrimidine, Indole, quinoline and isoquinoline.

Unit IV: Alkaloids and Terpenes **10 Hrs**

Natural occurrence, General structural features, Isolation and their physiological action, Emde's modification, Structure elucidation and synthesis of Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral and α-terpineol.

Unit V: Pharmaceutical Compounds: Structure and Importance **9 Hrs**

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Phenacetin, Aspirin, Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol.Mechanism of Drug Action(brief idea), Sulpha drugs: sulphadiazine (sulpha pyrimidine), sulpha guanidine, sulphamethazine, sulpha pyridine.

BOOKS RECOMMENDED

- Organic Chemistry, Vol 2; Sixth Edition; I.L. Finar; Pearson Education, New Delhi, 2002.
- Lehninger Principles of Biochemistry; Seventh Edition; David L. Nelson, Michael M. Cox; W H Freeman, 2017.

PAPER CODE- CHY 413
Electrochemistry and Chemical kinetics
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. make the students understand the concept of conductance, related laws and applications of conductance measurement.

2. understand the concept of equilibrium of redox systems.
3. provide an in-depth knowledge of theories of chemical kinetics and mechanism of catalyzed reactions.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-413	**Electrochemistry and Chemical Kinetics**	**The students will be able to –** **CO108:** describe various theories and effects related to electrolytic dissociation and know various applications of conductance measurement. **CO109:** calculate cell EMF and other thermodynamic quantities of cell reactions. **CO110:** describe the characteristics of various types of cells and can illustrate various applications of concentration cell. **CO111:** explain experimental methods and theories of chemical kinetics. **CO112:** describe mechanism of catalyzed reactions	Interactive Lectures • Discussions • Tutorials, • Problem solving	Presentations by Individual • Student/ Group of Three • Students • Class Tests at Periodic Intervals. • Written assignment (s) • Semester End Examinatio n

CONTENTS

Unit I :Conductance **10 Hrs**

Arrhenius theory of electrolytic dissociation . Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinitedilution. Kohlrausch law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrati and (v) hydrolysis constants of salts

Unit II : Equilibrium in Redox System **9 Hrs**

Types of reversible electrodes – gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrodes; electrode reactions, Nernst equation, EMF of a cell and its measurements, computation of cell EMF, calculation of thermodynamic quantities of cell reactions (ΔG, ΔH & K), derivation of cell E.M.F. and single electrode potential; standard hydrogen electrode- reference electrodes, standard electrode potential, sign conventions, electrochemical series and its significance.

Unit III: Electromotive Force **8 Hrs**

Electrolytic and Galvanic cells: reversible and irreversible cells, conventional representation of electrochemical cells. Concentration cell with and without transport, liquid Junction potential, applications of concentration cell - valency of ions, solubility product, activity coefficient, potentiometric titrations. Definition of pH and pKa, determination of pH using hydrogen, quinhydrone and glass electrodes and by potentiometric method.

Unit IV :Chemical Kinetics **12 Hrs**

Introduction of reaction rate in terms of extent of reaction; rate constants, order and molecularity of reactions. Reactions of zero order, first order, second order, third order and fractional order, half life, mean life, Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate),Radioactive decay as first order reaction. Determination of order of a reaction by half-life and differential method, experimental methods of the determination of rate laws, Temperature dependence of rate constant. Arrhenius equation, energy of activation. Collision theory of reaction rates.

Kinetics of complex reactions (integrated rateexpressions up to first order only): Opposing reactions, parallel reactions and consecutive reactions. Rate-determining and steady-state approximation – explanation with suitable examples.

Unit V Catalysis **6 Hrs**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

BOOKS RECOMMENDED

- A Textbook of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2007.
- Elements of Physical Chemistry; Seventh International Edition. P.W. Atkins, J. Paula; Oxford, India 2017.
- Elements of Physical Chemistry; Seventh Edition. P.W. Atkins, J. Paula; Oxford University Press, New York, 2016.
- Physical Chemistry; Fourth Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 2004.
- Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Second Edition;New Age International Pvt. Ltd, New Delhi, 2001.

PAPER CODE- CHY 414
Analytical Chemistry
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. make the students understand the concept of basic analytical techniques.
2. discuss optical methods of analysis and chromatographic separation techniques.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-414	**Analytical Chemistry**	**The students will be able to –** **CO113:** understand basic concepts and applications of Potentiometry, Electrogravimetry and Coulometry. **CO114:** explain basic concepts and know the applications of Polarography, Polarimetry and Solvent Extraction methods. **CO115:** illustrate various optical methods of analysis such as Spectrophotocolorimetry, Atomic absorption spectroscopy and Flame Photometry **CO116:** describe and classify various chromatographic methods. **CO117:** understand the principle and applications of various Chromatographic separation techniques like gas, liquid and ion exchange chromatography.	Interactive Lectures Discussions Tutorials Problem solving	Presentations by Individual Student/ Group of Three Students Class Tests at Periodic Intervals. Written assignment(s) Semester End Examination

CONTENTS

Unit I: Basic Analytical Techniques I **9 Hrs**

Potentiometry– Basic concepts and Applications in Acid-base titrations, oxidation-reduction titrations, precipitation titrations and complexometric titrations.

Electrogravimetry-Basic concept: current density, polarization, decomposition voltage, electrolysis at constant current and constant voltage and its basic applications.

Coulometry-Basic concepts: constant current coulometry, constant potential coulometry, applications in neutralization titration, precipitation titration, oxidation- reduction titration.

Unit II: Basic Analytical Techniques II **9 Hrs**

Polarography – introduction, polarographic measurement, half wave potential, residual current, migration current, diffusion current, Ilkovic equation, polarographic cell and dropping mercury electrode. Precautions and advantages, applications in quantitative and qualitative analysis.

Polarimetry- polarization of light, optical activity, angle of rotation, specific rotation, measurement of rotatory power (instrumentation), application of polarimetry in quantitative and qualitative analysis.

Solvent extraction- distribution law, process of extraction (liquid- liquid, solid-liquid), techniques for solvent extraction, classification and applications.

Unit III : Optical Methods of Analysis **9 Hrs**

Pre requisite: Lambert and Beer law, verification, derivation, signification of λ_{max} and molar absorptivity, theory of fluorescence and phosphorescence.

Spectrophotocolorimetry: single beam and double beam spectrophotometers, functions of the components, applications.

Atomic absorption spectroscopy: principle, instrumentation, spectral interferences and chemical interferences in atomic absorption spectroscopy, applications in quantitative analysis (analysis of Zn^{2+}, Cu^{2+} and Pb^{2+}).

Flame photometry: principle, instrumentation, interferences in flame photometry, applications in quantitative analysis. Comparison of atomic absorption and flame emission spectroscopy.

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Unit IV: **Chromatographic Separations I** **9 Hrs**

General description and classification of chromatographic methods, thin layer, paper and column chromatographic techniques and their simple applications, Rf-values and their significance, elution in column chromatography, migration rates of solutes, band broadening and column efficiency, column resolution.

Unit V Chromatographic Separations II **9 Hrs**

Principle, instrumentation, and applications of gas chromatography, high performance liquid chromatography and ion exchange chromatography

BOOKS RECOMMENDED

- Instrumental Methods of Analysis; Seventh Edition;Willard, Hobert H. et. al, CBS, 2004.
- Analytical Chemistry, Seventh Edition,Christian, Gary D; John Willy New York, 2013.
- Exploring Chemical Analysis, Fifth Edition;Harris, Daniel C; W.H.Freeman, New York, 2012.
- Basic Concepts of Analytical Chemistry; Fourth Edition;Khopkar, S.M.,New AgeInternationalPvt Ltd, 2020.
- Principles of Instrumental Analysis;Seventh Edition; Skoog, D.A., Holler F.J. and S.R. Crouch; Cengage Learning, USA, 2016.
- Laboratory Hand Book of Chromatographic & Allied Methods; Mikes, O. &Chalmes, R.A;Halsted Press; 1979.
- Analytical Chemistry-Methods of Separation; Ditts, R.V.; Van Nostrand, 1974.

PAPER CODE- CHY 415
Lab Course VII
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. provide ample training to develop experimental skills of various instruments (conductivity meter, pH meter) and hands on experience to solve kinetics experiments.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-415	**Laboratory Course VII**	**The students will be able to –** **CO118:** prepare solutions of desired concentrations. **CO119:** apply the knowledge of conductivity and pH measurement to perform the experiments based on pH-metry and conductometry. **CO120:** perform experiments and analyse the results to predict kinetics.	Approach in teaching: • Demonstration • Learning activities for the students: • Experimentation • Observations • Group Activity	The oral and written examinations (Scheduled and surprise tests) • Quiz • Presentations • Individual and group projects

CONTENTS

Minor Experiment

a) Titration of Strong/weak acid against NaOH pH metrically.
b) Determine the dissociation constant of a weak acid.

c) Determine the solubility and solubility product of a sparingly soluble salt like $BaSO_4$, or $PbSO_4$ or AgCl in water conductometrically.

d) i) Determination of cell constant of a given cell.

ii) Determination of specific and equivalent conductance of the given electrolyte (NaCl) at different

dilutions.

e) Titration of Strong/weak acid against Strong/weak base conductometrically

Major Experiment

a) First Order Kinetics- To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.

b) Second Order Kinetics- Saponification of ethyl acetate.

c) To study the effect of acid strength on the hydrolysis of an ester.

d) To study kinetically the reaction rate of decomposition of iodide by H_2O_2.

e)Titrate a tribasic acid (H_3PO_4) against a strong base (NaOH).

f) Determine the composition of mixture of HCl and Acetic acid conductometrically using NaOH.

BOOKS RECOMMENDED

- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi,2003.
- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B. Yadav; Goel Publishing House, Meerut, 2015.
- Advanced Practical Chemistry; Eighth Edition; JagdambaSingh, L.D.S Yadav, R.K.P. Singh, Jaya Singh; Pragati Prakashan 2018.

PAPER CODE- CHY 416

Lab Course VIII

(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. make the students understand the concept of quatitative gravimetric analysis method.
2. provide an in-depth knowledge of various chromatographic techniques.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-416	**Laboratory Course VIII**	**The students will be able to –** **CO121:** apply quantitative gravimetric analysis method. **CO122:** estimate percentage and number of functional groups by quantitative analysis method. **CO123:** separate green leaf pigments by TLC and ascending paper chromatography. **CO124:** apply circular paper chromatography and column chromatography.	Interactive Lectures • Discussions • Tutorials • Substantial laboratory-based practical component and experiments	Lab Tests and viva voce at Periodic Intervals. • Semester End Examination

CONTENTS

Quantitative Analysis: Gravimetric Analysis (Any Three)

a) Estimation of Cu as CuSCN,

b) Estimation of Zn as Zinc ammonium phosphate,

c) Estimation of Pb as $PbCrO_4$

d) Estimation of Ni as $Ni(DMG)_2$

Quantitative Analysis: Estimation of functional groups

a) Determination of the percentage and number of hydroxyl groups in an organic compounds by acetylation method.
b) Estimation of amines/phenols using bromated/bromide solution.

Chromatography

a) Separation of 2,4 –dinitrophenylhydrazones of acetone, 2-butanone, hexan-2- one and hexane-3-one using toluene and light petroleum (40:60) by TLC

b) Separation of green leaf pigments (spinach leaves may be used) by TLC

c) Separation of green leaf pigments (spinach leaves may be used) by ascending paper chromatography

d) Separation of amino acids or carbohydrates by circular paper chromatography.

e) Separation of mixture of organic compounds by column chromatography

BOOKS RECOMMENDED

- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.

PAPER CODE- CHY 511
Inorganic Chemistry V
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. develop a vast knowledge of structure, bonding, stability and reaction mechanism involved in metal complexes including metal carbonyls and nitrosyls.
2. provide in-depth knowledge of the mechanism involved in homo and heterogeneous catalysis.

3. acquaint them with the promising future of organo-transition metal chemistry in industrial, biological and environmental fields

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-511	**Inorganic Chemistry V**	**The students will be able to –** **CO125:** describe LCAO concept and sketch MO diagram of triatomic molecules compare MO diagrams of different geometries of complexes. **CO126:** define stability of complexes and compare thermodynamic with kinetic stability of complexes and discuss reaction mechanism of transition metal complexes and explain trans effect and its applications **CO127:** apply 18-electron rule to rationalize the stability of organometallic compounds **CO128:** know about the important preparations of organometallic compounds and structural features of the metal alkyls, aryls and sandwich compounds. **CO129:** develop a general idea of catalysis and describe in detail the mechanism of various homogeneous and heterogeneous organometallic catalysts **CO130:** interpret the structure and bonding involved in metal carbonyls and metal nitrosyls	Class lectures • Tutorials • Group discussions • Peer teaching and learning • Question preparation • Subjective type ▪ Long answer ▪ Short answer • Objective type ▪ Multiple choice questions ▪ One answer/two answer type questions • Assertion and reasoning	The oral and written examinations (Scheduled and surprise tests) • Closed book and open book tests • Problem solving exercises • Assignments • Quiz • Semester End Examination

CONTENTS

Unit I: Molecular Orbital Theory **10 Hrs**

Metal-ligand bonding (MO concept) in triatomic molecules- H_2O and BeH_2, LCAO approximation, ligand group orbitals, sigma bonding in octahedral, tetrahedral, square planar complexes (qualitative pictorial approach)

Unit II :**Stability and Reaction Mechanism** **10 Hrs**

Reactivity and stability: Thermodynamic and Kinetic Stability of Metal Complexes, labile and inert complexes, factors affecting the stability of complexes, ligand substitution reactions: patterns of reactivity, classification of mechanisms, energy profile of reaction transition states, mechanism of substitution reactions(acid hydrolysis) in octahedral complexes in Co(III) complexes, mechanism of ligand substitution reactions in square-planar complexes of Pt (II), the trans-effect, theories and its uses.

Unit III : Organotransition Metal Chemistry **9Hrs**

Definition, nomenclature and classification of organometallic compounds; Hapticity(η) of organometallic ligands, 18-electron rule.

Preparation, properties, structure, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti (η1)

Structure and bonding in metal ethylenic complex – Zeise's salt (η2)

Structure and bonding in metal cyclopentadienyl complex- Ferrocene(η5)

Unit IV: Catalysis **9Hrs**

Principles and Important Reactions of Transition Metal Organometallics: Coordinative unsaturation: oxidative addition and insertion reactions.

Homogeneous catalysis*:* hydrogenation of alkenes, hydrosilylation of alkenes, oligomerization and polymerization of alkenes and alkynes, hydroformylation of alkenes and polymerization of alkenes (Ziegler-Natta catalysis).

Heterogenous catalysis: Fisher-Tropsch synthesis, water-gas shift reaction

Unit V :Metal Carbonyls and Nitrosyls **7Hrs**

Introduction to π acceptor ligands; definition, classification, general methods of preparation, properties structure and nature of bonding in metal carbonyls (mononuclear carbonyls only),synergic effect (MO diagram of CO), Carbonylate anions and its reactions.

general methods of preparation, properties structure and nature of bonding in metal nitrosyls

BOOKS RECOMMENDED

- Organometallic Chemistry: A Unified Approach; Second Edition; R.C. Mehrotra and A.Singh; New Age International Private Limited, New Delhi, 2000.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Inorganic Chemistry; Fifth Edition; Gary L. Miessler and Donald A. Tarr; Pearson Education Inc. Singapore, 2013.
- Inorganic Chemistry (Principle and Structure and Reactivity); Fourth Edition; J. E Huheey, E. A. Keiter, R. L. Keiter; Pearson India, New Delhi, 2013
- Advanced Inorganic Chemistry, Sixth Edition; F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann; John Wiley and Sons, USA, New York, 2007.

PAPER CODE- CHY 512
Biomolecules
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1.enable the learners to understand the basic processes which link the biological systems with the chemical systems.

2. provide them with the basic knowledge and insight about the three-dimensional (3D) structure of macromolecules

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-512	**Biomolecules**	**The students will be able to –** **CO131:** discuss the structures, preparations and chemical reactivities of polynuclear hydrocarbons **CO132:** identify the chemical elements and functions of carbohydrates and interconvert & differentiate between simple and complex structures of the same. **CO133:** sketch a detailed account of nucleic acids and their components with special emphasis on polynucleotides like DNA and RNA. **CO134:** summarize the functions of amino acids, peptides & proteins and identify the influence of the threedimensional shape and subunits of a protein on its function. **CO135:** acquire perspective on the composition and functioning of lipids with reference to their characteristic properties like iodine value, saponification, hydrogenation and reversion.	Interactive Lectures • Demonstrations • Discussions • Tutorials • Quiz • Problem solving	Continuous Assessment (Written test) • Quiz • Closed book and open-book tests • Assignment • Group Activity • Semester End Exam

CONTENTS

Unit I: Polynuclear Hydrocarbons **7 Hrs**

Structure, preparation, important reactions and derivatives of naphthalene, anthracene and phenanthrene.

Unit II: Carbohydrates **10 Hrs**

Occurrence, classification and their biological importance

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff & Wohl degradation.

Disaccharides – Structure of maltose, lactose and sucrose,α& β glycosidic linkages, reducing & non-reducing sugars

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Unit III: Nucleic Acids **8 Hrs**

Components of nucleic acids (DNA and RNA), nucleosides and nucleotides; double helical structure of DNA, Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Unit IV: Amino acids, Peptides and Proteins **8 Hrs**

Amino acids, Peptides and their classification : α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis;Glycoproteins.

Study of peptides: Determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups . Solid-phase synthesis, denaturation and renaturation.

Unit V: Lipids **6Hrs**

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats

and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

BOOKS RECOMMENDED

- Organic Chemistry, Vol 2; Sixth Edition; I.L. Finar; Pearson Education, New Delhi, 2002.
- Organic Chemistry; Seventh Edition; R. T. Morrison, R. N. Boyd, S.K. Bhattacharjee; Pearson Education India, New Delhi, 2010.
- Lehninger Principles of Biochemistry; Seventh Edition; David L. Nelson, Michael M. Cox; W H Freeman,2017

PAPER CODE- CHY 513
Quantum mechanics
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
1.learn principal concepts of quantum mechanics and establish relationship between physical properties and molecular structure.

2. understand basic concept and applications of computational chemistry

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-513	**Quantum Mechanics**	**The students will be able to –** **CO136:** identify limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems. **CO137:** develop an understanding of quantum mechanical operators, quantization, probability distribution. **CO138:** setup and solve Schrodinger equation for simple systems such as the one electron system, harmonic oscillator, and rigid rotor. **CO139:** interpret the physical form of orbitals from their mathematical descriptions. **CO140:** normalize simple wave function and calculate average physical property for system like energy, momentum etc. **CO141:** describe chemical bonding theories in quantum mechanical approach. **CO142:** know the concept of computational chemistry.	Interactive Lectures • Demonstrations • Discussions • Tutorials • Quiz • Problem solving	Continuo us Assessment (Written test) • Quiz • Closed book and open book tests • Assignment • Group Activity • Semester End Exam

CONTENTS

Unit I Quantum Chemistry I **6 Hrs**

Pre requisite- Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids;Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect, de Broglie hypothesis, Heisenberg's uncertainty principle.

Theory of Wave motion: Classical Waves and Wave equation, Stationary Waves and Nodes, Schrodinger equation, Wave function and its physical meaning, Condition of Normalisation and Orthogonality, Quantum mechanical operators, Eigen values and Eigen functions, Basic Postulates of Quantum mechanics,

Unit II:Quantum Chemistry II **12 Hrs**

Application of Schrodinger equation to-

Free particle and particle-in-a-box (rigorous treatment), One dimensional box, quantization of energy levels, zero-point energy and justification for Heisenberg Uncertainty principle; Extension to two and three dimensional boxes, degeneracy, wave functions, probability distribution functions, nodal properties,

Simple harmonic oscillator model of vibrational motion: Classical treatment, Quantum mechanical treatment: Setting up of Schrodinger equation and discussion of solution and wavefunctions, Comparison of Classical and Quantum mechanical results.

Rigid rotator model of rotation of diatomic molecule.

Unit III: Quantum Chemistry II **10 Hrs**

Schrodinger equation, transformation tospherical polar coordinates. Separation of variables. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrodinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression), radial distribution functions of 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals and polar plots of their shapes.

Unit IV: Chemical Bonding **12 Hrs**

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Calculation of Energy levels from wave functions, Physical picture of bonding and antibonding wave functions. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Hybrid orbitals- sp, sp2, sp3, calculation of coefficients of AO's used in these hybrid orbitals.

Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Qualitative MO theory and its application to AH_2 type molecules. Simple Huckel Molecular Orbital (HMO) theory and its application to simple polyenes (ethene, butadiene).

Polarization– Dipole moment, Induced dipole moment, dipole moment and structure of molecules, Clausius-Mossotti equation.

Unit V: An Introduction to Computational Chemistry **5 hrs**

An overview of computational chemistry, molecular mechanics, electronic structure method, semi-empirical, ab initio and density functional methods, principle of model chemistry, desirable features of a model chemistry.

BOOKS RECOMMENDED

- Quantum Chemistry; Fourth Edition; R.K. Prasad; New Age International (P) Ltd, New Delhi, 2009.
- Molecular Quantum Mechanics, Fifth Edition; P.W. Atkins, and R.S. Friedman; OxfordUniversity Press Club, New York, 2012.
- Introductory Quantum Chemistry; Fourth Edition A. K. Chandra; Tata McGraw-Hill, 2017.
- Atoms, Molecules and Spectrum; S.K.Dogra and H.S.Randhawa;New Age International (P) Ltd, New Delhi, 2011.
- Quantum Chemistry; Seventh Edition; Ira N. Levine; Pearson Education India , New Delhi, 2016.
- Physical Chemistry, A Molecular Approach, First Edition; D.A. Mc Qurrie and J.D Simon; Viva

PAPER CODE- CHY 514
Research Methodology
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. enable the learners to imbibe the basic concepts and methodology of literature survey, scientific writing and Intellectual Property Rights.
2. equip them with the technical knowledge of relevant computer based software.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-514	**Research Methodology**	**The students will be able to –** **CO143**: know the different methods of carrying out a literature survey **CO144**: write and prepare a scientific document accurately **CO145**: draw and incorporate chemical structures into their documents using softwares like Chem Draw and MS Excel **CO146** : gain perspective on various domains of IPR and their legalities while outlining their economic essence in the current research community	Interactive Lectures • Demonstrations • Discussion s • Tutorials • Quiz Problem solving	Continuous Assessment (Written test) • Quiz • Closed book and open-book tests • Assignment • Group Activity • Semester End Exam

CONTENTS

Unit I: Literature survey **10 Hrs**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Author Index.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, , Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki- databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Unit II: Scientific Writing **8 Hrs**

Writing scientific papers- justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publication of scientific work, writing ethics, avoiding plagiarism**.**

Unit III: Software Application in Chemistry **9 Hrs**

Incorporation of chemical structures into word processing documents using ChemDraw and Microsoft chemistry add-in software,use of reference tab in MS word: creating table of content, adding footnote and caption.

Use of spreadsheet (Excel) for simple calculations, plotting graphs using a spreadsheet (radial distribution curves for hydrogenic orbitals, gas kinetic theory, pressure-volume curves of vander Waals gas, graphical solution of equations),solving equations numerically (e.g. pH of a weak acid ignoring/not ignoring the ionization of water,volume of a vander Waals gas, equilibrium constant expressions).

Unit IV: Intellectual Property Rights - I **9 Hrs**

Historical Perspective, Different Types of IP and the concern IPR, Objectives of IPR, Economic Value of Intellectual Property – Intangible assets and their valuation, Importance of protecting IP - Licensing and technology transfer, Limitations of IPR; Different International agreements: Paris Convention, Berne Convention, WIPO, PCT system, World Trade Organization (WTO) and Trade Related Intellectual Property Rights (TRIPS) agreement; Various laws on IPR in India, IP Infringement issue and enforcement – Role of law enforcement agencies – Police, Customs, Judiciary etc.

Unit V: Intellectual Property Rights -II **9 Hrs**

Copyrights, Trade Marks: Different types of marks, Patents and parts of patent application,

Industrial Designs, Geographical Indications, Layout design of integrated circuits, Trade Secrets, Biodiversity related IPR issues, Plant Breeders Rights, Traditional Knowledge, bio-piracy, TKDL, Differences of one IPR from another.

BOOKS RECOMMENDED

- Research Methodology and Scientific Writing; C. G. Thomas, Ane Books Pvt. Ltd, New Delhi 2016.
- www.wipo.int
- www.ipindia.nic.in
- Intellectual Property: Patents, Trademarks and Copyright in a Nutshell; Arthur Raphael Miller, MichealH.Davis; West Group Publishers, 2000.
- The Law of Patents-With a Special Focus on Pharmaceuticals in India; *Feroz*Ali Khader*;*Lexis Nexis Publication, *2007.*
- Intellectual property rights in the WTO and developing countries; Jayashree Watal; Oxford University Press, Oxford.
- Intellectual property law*;* Lionel Bentlyand Brad Sherman; Oxford Publication, 2004.
- Understanding Trips: Managing Knowledge in Developing Countries; Manjula Guru & M.B. Rao; Sage Publications, 2003.

- Manual for Patent practices (www.ipindia.nic.in)
- Patent Law Practices and Procedures; N R Subbaram; Lexis Nexis Publication, 2007.
- Textbook on intellectual property rights; N.K. Acharya; Asia Law House, 2001.
- Intellectual Property Law; P Narayanan; Eastern Law House, 2001.
- Intellectual Property Rights: Unleashing the Knowledge Economy; P. Ganguli; TataMcGrawHill, 2001
- Intellectual Property Rights; Prateek Kasliwal; College Book Centre, 2009.
- Intellectual Property Rights in India; VK Ahuja;Lexis Nexis Publication, 2009.

PAPER CODE- CHY 515
Lab Course IX
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. provide knowledge of synthesis by conventional and non-conventional methods.
2. acquaint students with the basic common laboratory techniques.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-515	**Lab Course IX**	**The students will be able to –** **CO147:** demonstrate and apply common laboratory techniques including refluxing, distillation, recrystallization, vacuum filtration, extraction, thin layer chromatography in the specific synthesis **CO148:** synthesize various organic compounds through conventional methods as well as green methods	• Class Lecture • Discussion • Demonstration • Substantial laboratory-based practical component and experiments	• Continuous Assessment (practical test) • Viva Voce • Semester End Exams

CONTENT

Basic techniques involved in synthetic organic chemistry 90 hrs

i. Different types of glass wares
ii. Filtration
iii. Distillation (distillation at atmospheric pressure, steam distillation, fractional distillation and distillation at reduced pressure).

iv. Recrystallization and melting point correction.
v. Use of decolourising carbon.
vi. Thin layer chromatography.

Synthesis (Green /Conventional))

a. One step synthesis

i. **Aldol condensation** : Synthesis of dibenzal propanone
ii. **Acetylation** : Synthesis of acetanilide from aniline
iii. **Pechmann Condensation for Coumarin synthesis** : Clay catalysed solid state synthesis of 7-hydroxy -4-methyl coumarin
iv. **Diazotisation** : Preparation of Methyl orange/Methyl red
v. **Aromatic Electrophilic Substitution** : Bromination of Phenol
vi. **Rearrangement** : Preparation of Phenytoin from Benzil and Urea

b. **Two step synthesis**

i. Benzoin → benzil → benzilic acid (calculation of atom economy required).

ii. Benzophenone → benzopinacol → benzapinacolone

iii. Acetanilide → p-bromoacetanilide → p-bromoaniline

iv. Acetanilide→ p-nitro acetanilide→ p-nitro aniline

v. Pthalic ⟶ anhydride ⟶ Pthalimide ⟶ Anthranilic Acid

BOOKS RECOMMENDED

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.
- Monograph on Green Chemistry- Laboratory Experiments- Laboratory Task Force Committee , DST
- University Practical Chemistry; Second Edition; P.C.Kamboj, Vishal Publishing House,New Delhi; 2019.

PAPER CODE- CHY 516
Communication Skill seminar
(Seminar)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. enable the students to demonstrate a clear and exhaustive understanding of the basic concepts of grammar with a special focus on technical communication and subject-specific skills.

2. ensure the enhancement of their ability to read, assimilate and discuss scholarly articles and research papers showcasing chemistry as well as the interdisciplinary areas of sciences and to

develop strong oral and written communication skills to present their ideas effectively through power-point presentations and appropriate software for the analysis of data.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-516	**Communication skill**	**The students will be able to –** **CO149**: read and emulate the documents with in- depth analyses and logical arguments which further enhances their interaction with both specialized and non specialized audiences on a specific idea or concept. **CO150**: apply the latest subject matter, both theoretical as well as practical, ina way to foster their core competency and discover true learning **CO151:** examine specific phenomena theoretically and /or experimentally to contribute to the generation of new scientific insights or the innovation of new applications of research in chemistry **CO152:** identify their domain-independent knowledge with a focus on critical thinking and communication.	• Class lectures • Tutorials • Group discussions • Seminar • Power point presentation • Report writing	• Power point presentation by individual student • Mock Interview • Group Discussions • Viva voce

CONTENTS

Unit I: Grammar **12 hrs**

Conditionals/Tenses
Relative Clauses
Subject – Verb Agreement
Passive Voice

Unit II : Written Communication **12 hrs**

Discuss a topic of general interest, but related to science in about 300 words.
(Analyse, Comment, Argue, Reflect, Persuade, etc.)
(can also be used for oral presentations by the students, followed by discussion)

Unit III: Scientific Writing **10 hrs**

Writing a Scientific Report on a project undertaken or an experiment conducted (Theory + Practice)

Unit IV:Oral Communication I **6 hrs**

a) Consulting a dictionary for correct pronunciation (familiarity with Phonetics Symbols and Stress-marks only)
b) Dialogue

Unit V:Soft Skills **20 hrs**

1. **Gestures/ postures** – Body language, gesture, posture.
2. **Group discussion** – Giving up of PREP, REP Technique, how body language during group discussion.
3. **Presentation Skills**
   a) How to make power point presentation
   b) Body language during presentation
4. **Resume writing**
   a) Cover letter, career objective
   b) Resume writing (tailor made)
5. **Mock Interview**
   Each student to face an interview and to demonstrate the above taught skills.
6. **Positive Attitude**
   Positive skills enhancement with power point presentation.

BOOKS RECOMMENDED

- Advanced English Usage; Quirk & Greenbaum; Pearson Education.
- Developing Communication Skills; Second Edition; Meera Banerjee& Krishna Mohan; Macmillan Publications, 2009
- Business Communication; Third Edition ; P. D. Chaturvedi; Pearson Publications; 2013
- Business Communication; M.J. Mathew; RBSA Publications, 2005
- Communication of Business; Taylor, Shirley; Pearson Publications
- Soft Skills : ICFAI Publication
- Dictionary Oxford

PAPER CODE- CHY 611
Inorganic Chemistry VI
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. make students understand about the basics of group theory.
2. apprise the students about the nuclear chemistry.
3. aacquaint them with the fundamental concepts of supramolecular chemistry
4. make students appreciate the vitality of metal ions in biosystems. familiarize them with the importance of organic and inorganic polymers

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-611	**Inorganic Chemistry VI**	**The students will be able to:** **CO153:** determine the point groups of different molecules by applying the concepts of various symmetry elements and operations. **CO154:** calculate the binding energy of nucleus, learn about the types of nuclear reactions and applications of radioisotopes. Calculate the binding energy of nucleus, learn about the types of nuclear reactions and applications of radioisotopes. **CO155**: discuss the fundamental concepts of supramolecular chemistry **CO156:** differentiate between bulk and trace elements and explain the importance of metal ions in biological systems. **CO157:** classify the types of organic and inorganic polymers and compare the preparation and properties of the above two	• Class lectures • Tutorials • Group discussions • Multimedia presentations • Question preparation • Subjective type • Long answer • Short answer • Objective type • Multiple choice questions • One answer/two answer type questions • Assertion and reasoning	• The oral and written examinations (Scheduled and surprise tests) • Closed-book and open-book tests • Problem-solving exercises • Assignments • Quiz • Semester End Examination

CONTENTS

Unit I : Symmetry and Group Theory **9 Hrs**

Symmetry elements and symmetry operations, groups and subgroups, relation between orders of a finite group and its subgroup, conjugacy relation and classes, point group.

Unit II: Radioactivity **10 Hrs**

Atomic Nucleus: mass defect. Nuclear forces: meson exchange theory. Nuclear models (elementary idea : Shell model and Liquid drop model) Concept of nuclear quantum number, magic numbers. Natural radioactivity, Radioactive disintegration series, group displacement law, law of radioactive decay, half-life of radio elements. Nuclear Reactions; Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Separation and uses of isotopes. Radio chemical methods: principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures.

Unit III : Bioinorganic Chemistry **9 Hrs**

Elements of life: Essential, major and trace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+} ,Ca^{2+}, $Fe^{3+/2+}$,$Cu^{2+/+}$, and Zn^{2+}).Metal ion transport across biological membrane, Na^+-ion pump, ionophores.

Biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carbonate - bicarbonate buffering system and carbonic anhydrase. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II.

Unit IV: **Supramolecular Chemistry** **8 Hrs**

Definition and development of supra molecular chemistry, classification of host guest compounds, nature of supramolecular interactions: ion-ion, dipole-ion and dipole-dipole; cation binding hosts, binding of anions, neutral molecules, organic molecules. Molecular recognition: molecular receptors for different types of molecules

Very weak, weak and strong hydrogen bonds, utilization of H-bonds to create supramolecular structure. arisonic substrates, design and synthesis of coreceptor molecules and multiple recognition;

Unit V: Polymers **9 Hrs**

Inorganic Polymers- Types, comparison with organic polymers, synthesis, structural aspects and applications of silicones, phosphazenes, and tetrasulphur tetranitride.

Organic Polymers- Classification, condensation and addition polymerizations – mechanism of free radical, cationic, anionic addition polymerization; Ziegler-Natta catalyzed reactions, stereochemistry and kinetics; vinyl polymers (PVC, poly vinyl acetate, polystyrene), teflon, urea-formaldehyde resin and phenol-formaldehyde resins, polyurethanes; synthetic fibres– nylon-66, nylon-6, polyester, polyacrylic fibres; plasticizers; natural and synthetic rubber, vulcanization.

BOOKS RECOMMENDED:

- Symmetry and Spectroscopy of Molecules; Revised Second Edition; K. Veera Reddy; New Age Publishers, New Delhi, 2009.
- Chemical Applications of Group Theory; Student Third Edition; F.A. Cotton; Wiley-India(P) Ltd, New Delhi, 2008.
- Inorganic Chemistry; Fifth Edition; Gary L. Miessler and Donald A. Tarr; Pearson Education Inc. Singapore, 2013.
- Advanced Inorganic Chemistry, Sixth Edition; F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann; John Wiley and Sons, USA, New York, 2007.
- Principles of Bioinorganic Chemistry; First Edition; S. J. Lippard, J.M. Berg; Panima Publishing Corporation, New Delhi, 2005.
- Polymers; David Walton and Philip Lorimer; Oxford University Press, 2001.
- Introduction to Polymers; Third Edition R.J. Young and P.A. Lovell; Nelson Thornes, United Kingdom, 2011.
- Essentials of Nuclear Chemistry ; Fourth Edition ; H.J. Arnikar; New Age International(P) Ltd., New Delhi, 2011.

PAPER CODE- CHY 612
Spectral Techniques in Organic
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. apprise the learners with the instrumentation involved in the various spectroscopic techniques.
2. enable them to understand and apply the key concepts of spectroscopy in the elucidation, characterization and inference of the relevant structural information of various known organic molecules and to make them extend the same to unknown organic compounds.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY612	**Spectral Techniques in Organic Chemistry**	**The students will be able to –** Learners will be able to- **CO158**: differentiate between the principles of various spectroscopic methods and work on problems of different regions of EMR Spectrum. **CO159:** identify the suitable technique for a class of molecules based on selection rules and fundamental theory of spectroscopy. **CO160:** differentiate between compounds of different electronic, structural and functional constitution in 13C-NMR using the basic theoretical knowledge of techniques like COSY and NOSEY **CO161:** interpret and distinguish between the structures of simple compounds using the Mass, IR and NMR spectra. **CO162:** predict the λmax for different organic compounds using	• Interactive Lectures • Demonstrations • Discussions, • Tutorials • Quiz Problem solving	• Continuous Assessment (Written test) • Quiz • Closed-book and open-book tests • Assignment • Group Activity • Semester End Exam

		Woodward-Feiser rules. **CO163:** associate advanced applications like MRI with the NMR principles and theory.		

CONTENTS

Unit I: Basic Elements of spectroscopy & UV Spectroscopy 9 Hrs

General principles : Different regions of electromagnetic radiation, quantisation of energy, regions of the spectrum. Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λ_{max}, chromophores and auxochromes, bathochromic and hypsochromic shifts, intensity of absorption, application of Woodward Rules for calculation of λ_{max} for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); Distinction between cis and trans isomers.

Unit II : IR Spectroscopy 8 Hrs

Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H- bonding, conjugation, effect of resonance and ring size on IR absorptions; Fingerprint region and its significance; Overtones, Fermi resonance , Applications in functional group analysis.

Unit III: ^{1}H NMR Spectroscopy 10 Hrs

Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics; Interpretation of NMR spectra of simple compounds like ethyl acetate, ethyl alcohol, acetaldehyde, 1,2 dibromo ethane, ethyl bromide etc.

Unit IV: ^{13}C NMR Spectroscopy and Combined Applications 8 hrs

^{13}C NMR spectroscopy: general considerations, chemical shift, (aliphatic, olefinic, alkyne, aromatic, heteroaromatic & carbonyl carbon), proton (^{1}H) coupled ^{13}C NMR spectrum, off resonance (elementary idea of ^{2}D NMR spectroscopy: COSY, NOESY NMR spectra), Structural determination of simple organic compounds using UV, IR &^{1}H NMR spectral data.

Unit V: Mass Spectroscopy 10 Hrs

Introduction, instrumentation, molecular ion-production, determination of molecular weight – molecular ion peak, base peak, nitrogen rule, isotope peak, metastable ions; fragmentation – basic fragmentation types and rules, factors influencing fragmentation, McLafferty rearrangement, fragmentation pattern of hydrocarbons, alcohols, ethers, ketones, aldehydes, carboxylic acids, amines, nitro compounds, alicyclic and heterocyclic compounds.

BOOKS RECOMMENDED

- Spectrometric Identification of Organic Compounds, Eighth Edition; R.M. Silverstein, F.X. Webster, David J.Kiemie and David L. Bryce; John Wiley and Sons, Inc., Singapore, 2014.

- Applications of Spectroscopy; Third Edition; William Kemp; Palgrave Publisher Ltd., New York, 2004.
- Stereochemistry: Conformation and Mechanism; Tenth Edition; P.S. Kalsi; New Age International Publishers Pvt Ltd, New Delhi, 2019.

PAPER CODE- CHY 613
Spectroscopy and Statistical Thermodyamics
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. To make students familiar with the concepts taught in the theory paper

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 613	**Spectroscopy and Statistical Thermodynamics**	**The students will be able to:** **CO164**: discuss qualitative and quantitative knowledge of the fundamental concepts of spectroscopy. **CO165**: describe principle, selection rulesand applications of rotational, vibrational, Raman, electronic and NMR spectroscopy. **CO166**: analyse spectroscopic data for molecular characterization. **CO167**: select suitable statistics for a particular system. **CO168**: formulate thermodynamic properties in terms of partition function and their exact values for an ideal gas.	• Approach in teaching: • Interactive Lectures, • Explicit Teaching • Discussion Didactic questions, Tutorials • Multimedia Presentations, • Demonstration • Learning activities for the students: • Self learning Assignments, Peer Assessment, Concept mapping, • Think/Pair/Share, Problem Solving, Power Point Presentation, Handouts	• The oral and written examinations (Scheduled and surprise tests) • Closed book and open book tests • Quiz • Problem solving exercises • Assignments • Presentation • Semester End Examinations

CONTENTS

Unit I: Basic Elements of Spectroscopy 7 Hrs

Pre requisite: Interaction of electromagnetic radiation with matter. Characterization of

electromagnetic radiation, quantisation of energy, regions of the spectrum

Representation of spectra, basic elements of practical spectroscopy, signal-to-noise ratio – resolving power, line width – natural line broadening,Doppler broadening, Heisenberg uncertainty principle; intensity of spectral lines –transition probability, population of states, path length of sample; Born-Oppenheimer approximation; rotational, vibrational and electronic energy levels in molecules; transition moment, selection rules, Fourier Transform methods (IR and NMR)

Unit II :Rotational and Vibrational Spectroscopy 11 Hrs

Rotation spectroscopy*:* Selection rules, intensities of spectral lines, determination of bond

lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy*:* Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Unit III: Raman and Electronic Spectroscopy 8 Hrs

Raman spectroscopy*:* Qualitative treatment of Rotational Raman effect; Effect of nuclear spin,

Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference,

Electronic spectroscopy*:* Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Unit IV: Introduction to Statistical Thermodynamics 10 Hrs

Introduction, quantum mechanical aspects, common terms- canonical ensemble, occupation number, statistical weight factor, configuration, phase space, macroscopic state, microscopic; state, system, assembly and ensemble; statistical equilibrium, Boltzmann distribution law, type of statistics, Bose-Einstein statistics, Fermi-Dirac statistics.

Unit V: Statistical Approach to Thermodynamics Properties 9 Hrs

Partition Function :Molecular partition function for an ideal gas, translational partition function, rotational partition function, vibrational partition function, electronic partition function, nuclear partition function

Internal energy, enthalpy, entropy, helmholtz function, pressure, Gibbs functions, residual entropy, chemical potential, heat capacity of mono and diatomic gases

BOOKS RECOMMENDED

- Fundamentals of Molecular Spectroscopy, Fourth Edition.; C.N. Banwell&McCash.; Tata McGraw-Hill, New Delhi, 2017.
- Modern Spectroscopy, Fourth Edition.; J.Michael Hollas; Wiley,2003.
- Spectroscopy, H.Kaur,Pragati Prakashan,2017.
- Statistical thermodynamics, Revised Second Edition; M.C Gupta; New Age International Pvt Ltd., New Delhi, 1998.

PAPER CODE- CHY 614
Environmental and Green Chemistry
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. equip students with the knowledge of the chemical and photochemical reactions essential for the emergence and existence of the cycling and accumulation of pollutants in the environment.
2. address the chemistry of elements and compounds in the atmosphere and water.
3. lay special emphasis on the processes that define the connections and the dependence between individual segments of environment and to develop perspective on sustainability.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 614	**Environmental and Green Chemistry**	**The students will be able to –** **CO169**: discuss the concept of structure and function of different compartments of the environment and criticize the range and extent of the air and water pollution problem with an understanding of some of the treatment procedures available **CO170**: examine the national and global	• Class lectures • Tutorials • Group discussions • Peer teaching and learning • Question preparation • Subjective type Long answer Short answer • Objective	• The oral and written examinations (Scheduled and surprise tests) • Closed-book and open-book tests • Problem-solving exercises • Assignments • Quiz • Semester End Examination

		environmental issues relating to atmosphere, water and natural resources **CO171:** identify relationships between chemical exposure and effects on physiological system **CO172**: analyse the environmental impacts of chemistry and discover the impotance of Green Chemistry. **CO173**: apply the green chemical sustainable tools for cleaner environment & energy.	type • Multiple choice questions • One answer/two answer type questions • Assertion and reasoning	

CONTENTS

Unit I : General Aspects of Environmental Chemistry **9 Hrs**

Environmental components (atmosphere, hydrosphere, lithosphere and biosphere)

Atmospheric layers, vertical temperature profile, heat radiation budget of the earth. Temperature inversion.

Environmental pollution- Introduction, Pollutants- types & Classification.

Effects and control of air pollutants: CO, NO_x, SO_2 and particulates.

Biogeochemical cycles of carbon, nitrogen and oxygen, Residence time.

Chemistry of water and chemical reactions in aquatic environment; concept of oxygen demand -DO, BOD, COD; TDS, pH, conductivity

Unit II: Enhanced Atmospheric Effects **9 Hrs**

Green house effect: Green house gases - Major sources and climate change, effect on global

warming and agriculture.

Acid Rain: Introduction; acid rain precursor, their aqueous and gas phase atmospheric oxidation reactions; damaging effects on aquatic life, plants, buildings and health; acid rain control strategies.

Ozone depletion: Ozone layer formation, reactions, role, and processes of ozone depletion.

Consequences of ozone depletion. Creation, non-catalytic and catalytic process of ozone destruction.

Aerosols, Smog formation

Unit III: Environmental Toxicology **9 Hrs**

Introduction; threshold limiting value (TLV); Toxicity and control of Toxicants--

Non Metallic Compounds, Asbestos, Organic Compounds- POPs (phthalate, dioxins), PCBs, Pesticides, VOCs, endocrine disrupters, heavy metals-As, Hg, Cd, Pb.

Unit IV: Principles of Green Chemistry **I9 Hrs**

History, Need and Goals. Green Chemistry and Sustainability and background of Green Chemistry.

Twelve Basic principles of Green Chemistry with their explanation and examples and special emphasis on the following:

Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; Atom Economy: maximum incorporation of the materials used in the process into the final products, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.

Prevention/ minimization of hazardous/ toxic products reducing toxicity.

Risk = (Function) hazard x exposure; waste or pollution prevention hierarchy.

Unit V: Principles of Green Chemistry II **9 Hrs**

Green solvents: Supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.

Energy requirements for reactions: alternative sources of energy: Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride)

Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.

Selection of starting materials; avoidance of unnecessary derivatization-careful use of blocking/protecting groups.

Use of catalytic reagents in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

BOOKS RECOMMENDED:

- Environmental Chemistry, Tenth Edition; Stanley E. Manahan; CRC Press; 2017.
- Environmental Chemistry, Fifth Edition; Colin Baird; W.H. Freeman and company, New York, 2012.
- Environmental Chemistry, Ninth Edition; A. K. De; New Age International Pvt. Ltd., New Delhi, 2018.
- Chemistry of the Environment, Revised Third Edition; Thomas G. Spiro & William M. Stigliani; University Science Book, New Delhi, 2011.
- Green Chemistry:A textbook; V.K.Ahluwalia Narosa Publishing House, New Delhi, 2012.
- Green Chemistry: Introductory Text, Second Edition; M. Lancaster;Royal Society of Chemistry London, 2010.

PAPER CODE- CHY 615
Laboratory Course X
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. Get an insight of design elements
2. Knowledge of colours and colour ways to imply it to textile designing

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY-615	**Laboratory Course X**	**The students will be able to –** **CO174**: separate two liquid by distillation method. **CO175**: separate two/three solid organic compound mixture by different separation technique. **CO176:** purify and identify of component of a mixture of organic compound. **CO177:** perform Thin Layer Chromatography for checking the purity of separated organic compound.	• Class Lecture • Discussion • Demonstration • Substantial laboratory-based practical component and experiments	• Continuous Assessment (practical test) • Viva Voce • Semester End Exams

CONTENTS

Qualitative Analysis

Separation, purification and identification of components of a mixture of two and three organic compounds (Two/three solids, one/two solid and one liquid) using TLC for checking the purity of separated compounds.

BOOKS RECOMMENDED:

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.
- Organic Analytical Chemistry: Theory and Practice; JagMohan , Narosa Publishing House, New Delhi, 2014.

PAPER CODE- CHY 616
Lab Course XI
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. make the students to get an insight on the use of apparatus used in colorimetry like spectrophotometer and to enable them to record absorption spectrum of substances.
2. acquire knowledge of spectrophotometric estimations of proteins, carbohydrates and cholesterols

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 616	**Laboratory course XI**	**The students will be able to –** **CO178:** apply Beer's Law, relating solution concentration to absorbance and use the measurement of light absorption (colorimetry) to detect the colorimetric reaction of thiocyanate with iron **CO179:** acquire knowledge to determine the spectrophotometric estimations of protein**,** carbohydrate and cholesterol along with their calculations **CO180:** interpret the method of continuous variation to determine the reaction stoichiometry for the formation of a metal ion complex **CO181**: learn the technique of absorption spectroscopy in order to monitor the relative concentration of a colored metal ion complex in solution	• Class Lecture • Discussion • Demonstration • Substantial laboratory-based practical component and experiments	• Continuous Assessment (practical test) • Viva voce • Semester end examinations and observation

CONTENTS

Physical Chemistry Experiments

Colorimetry

a) Job's method of continuous variation by iron-phenanthroline complex.
b) Mole Ratio method by iron-phenanthroline complex.
c) Record an absorption spectrum of a substance ($KMnO_4/K_2Cr_2O_7$) using a spectrophotometer and determine absorption maxima (λ_{max}).
d) To verify the Beer-Lambert law for a compound(Potassium permanganate, copper sulphate, methylene blue etc.) and determine the concentration of the substance using calibration curve.

Polarimeter

e) Determine the rate constant of the inversion of cane sugar in presence of hydrochloric acid and sulphuric acid by using polarimeter and evaluate the relative strength of the two acids.

Spectrophotometric Estimations

i. Protein
ii. Carbohydrate
iii. Cholesterol

BOOKS RECOMMENDED:

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.D. Smith, A.R. Tatchell; Pearson Education, New Delhi, 2003.

- Advanced Practical Physical Chemistry; Eighteenth Edition; J.B. Yadav; Goel Publishing House, Meerut, 2015.

Programme- M.Sc. Chemistry
OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	**Critical thinking and Problem Solving:** Analyse the given scientific data critically and systematically and will have the ability to draw the objective conclusions. Know basics of cognitive biases, mental models, logical thinking, scientific methodology and constructing cogent scientific arguments. An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.
PO2	**Research Aptitude:** Keenly observe about what is going on in the natural surroundings to awake their curiosity and design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
PO3	**Employability:** Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	**Applicability:** Acquire the ability to engage in independent and self-learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO5	**Social Responsibility**: Students are trained to be an individual with concern for the society they live and to contribute at maximum, their skills and knowledge in the broadest context, for the development of the nation.
PO6	**Ethics:** Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Students are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Be responsible

	citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
PO7	**Life-long learning:** Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will also enable the graduate to prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will gain knowledge and skills for further higher studies, competitive examinations and employment.
PO8	**Digital Literacy: D**igitally literate to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
PO9	**Team Player:** Students will learn team workmanship with productive cooperation involving members from diverse socio-cultural backgrounds in order to serve efficiently institutions, industry and society.
PO10	**Transferable skills:** Develop various skills like Use of IT (word-processing, use of internet, statistical packages and databases), Communication of scientific ideas in writing and orally. Ability to work as part of a team, Ability to use library resources, time management and Career planning.
PO11	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and development of the information to provide valid conclusions.

PROGRAMME SPECIFIC OUTCOMES

The Master of Science in Chemistry programs offer students a quantitative experience in chemistry. The purpose of the undergraduate chemistry program at the IIS(deemed to be University)is to provide fundamental knowledge of the major fields of chemistry to students covering the general areas of inorganic, organic, and physical chemistry and all other related allied chemistry subjects including many more specialized courses . These students are exposed to applied laboratory techniques, critical thinking, independent and team learning, and are provided with research opportunities. The faculty is committed to providing an environment that addresses the individual needs of each student and encourages them to develop their potential. After the completion of the programme, students will be able to-

PSO1	have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. They will have extensive laboratory work and knowledge of Biological Chemistry.
PSO2	develop critical thinking and analytical reasoning as applied to scientific problems.
PSO3	develop skill in problem solving where the learner will develop the capability to function as a member of a problem solving team. The learner will be capable to – a. identify the issues. b. list the possible solutions (options) c. evaluate the options d. select a correct option(s)
PSO4	appreciate the understanding of safe handling of chemicals, toxic hazards, long term health effects from chemicals and environmental issues.
PSO5	foster the ability to focus different minds on the same problem, mutual support, commitment, accountability, conflict management, trust, focusing on results and increased efficiency in their personality.
PSO6	initiate, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.
PSO7	take ethical decisions, designate moral situations and dilemmas; critically analyze, evaluate, and additionally change one's own moral and ethical esteems; and look up the effects of one's own attitude for the lives of others.
PSO8	use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
PSO9	understand documents with in-depth analyses and logical arguments and can clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.

COURSE ARTICULATION MATRIX : (MAPPING OF COs WITH POs)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CHY-121	CO1	x		x						
	CO2	x	X				x			
	CO3	x	X				x		x	
CHY-122	CO4	x	X							
	CO5	x	x							
	CO6	x	x							x
	CO7	X		x			x			
	CO8	X	x						x	
	CO9	X	x				x			
CHY-123	CO10	X		x					x	
	CO11			x			x			
	CO12	x	x	x					x	
	CO13	x	x							x
	CO14	x				x				x
	CO15	x	x	x			x			
	CO16	x	x				x		x	
CHY-124	CO17	x	x				x			
	CO18	x	x			x				x
	CO19		x	x						
	CO20	x	x	x					x	
CHY-125(A)	CO21	x		x					x	
	CO22	x	x				x			
	CO23	x	x	x			x			
	CO24	x	x	x			x			
	CO25	x	x	x					x	
CHY-125(B)	CO26	x	x							x
	CO27	x								
	CO28	x								
	CO29	x					x			
	CO30	x	x							
	CO31	x					x			
CHY-126	CO32	x			x	x				
	CO33	x	x		x	x	x			x
	CO34	x	x	x	x	x				
CHY-127	CO35	x			x	x			x	
	CO36	x			x	x				
	CO37	x			x	x		x	x	x
	CO38	x			x	x		x		
CHY-128	CO39	x					x			x
	CO40						x	x		
	CO41		x					x	x	

	CO42	x	x					x		
CHY-221	**CO43**	x	x				x		x	
	CO44	X	x	x					x	
	CO45	X	x	x						
	CO46		x				x			x
	CO47		x	x						
	CO48		x	x			x		x	
	CO49	X	x	x		x	x			x
	CO50	X	x							
CHY-222	**CO51**	X					x			
	CO52									
	CO53		x							x
	CO54	X	x				x			x
	CO55	X	x							
	CO56	X	x				x			
CHY-223	**CO57**	X		x					x	
	CO58	X	x	x						
	CO59	X		x					x	x
	CO60	X		x			x			x
	CO61	X		x			x			x
	CO62	X					x			
CHY-224	**CO63**	X	x				x			
	CO64	X	x				x			
	CO65	X	x				x			
	CO66	X					x			
	CO67	X	x				x			
	CO68	x	x						x	
	CO69	x	x						x	x
	CO70	x						x	x	
CHY-225	**CO71**	x					x		x	
	CO72		x				x		x	
	CO73	x	x				x		x	
	CO74	x					x	x	x	x
	CO75	x	x	x			x		x	
CHY-226	**CO76**	x	x		x	x	x			
	CO77	x	x		x	x	x			
	CO78	x			x	x			x	
CHY-227	**CO79**				x	x	x			
	CO80	x	x	x	x	x	x			
	CO81	x			x	x	x			x
	CO82				x	x	x		x	
	CO83				x	x	x	x	x	x
CHY-228	**CO84**	x	x			x	x	x	x	
	CO85	x					x			
	CO86	x	x				x	x	x	

	CO87	x					x			x
CHY-321	**CO88**	x								
	CO89	x					x			x
	CO90	x	x							x
	CO91	x					x			
CHY-322	**CO92**	x								x
	CO93	x	x							x
	CO94	x								x
	CO95	x					x		x	
CHY-323	**CO96**	x	x				x			x
	CO97	x	x							
	CO98	x	x							x
	CO99	x	x							x
	CO100	x		x			x			
CHY-324	**CO101**	x					x			x
	CO102	x							x	x
	CO103		x				x		x	
	CO104	x							x	
CHY-325	**CO105**	x				x				x
	CO106	x				x	x	x		
	CO107	x				x		x		x
	CO108	x					x	x		x
	CO109	x	x					x		
	CO110	x		x		x	x	x		
CHY-326	**CO111**	x	x				x		x	
	CO112	x	x				x		x	
	CO113	x	x				x			x
CHY-327	**CO114**	x			x	x			x	
	CO115	x			x	x				
	CO116	x			x	x			x	
CHY-328	**CO117**	x			x	x	x			
	CO118	x		x	x	x	x		x	
	CO119						x		x	
	CO120		x				x			
	CO121	x	x	x	x	x	x			
	CO122	x		x	x	x	x		x	x
CHY-421	**CO123**	x	x							x
	CO124	x	x				x			
	CO125	x	x							
	CO126	x					x	x	x	
	CO127	x					x	x	x	
CHY-422	**CO128**	x	x	x	x		x	x		
	CO129	x	x	x	x		x	x		
	CO130		x	x						

CHY-423(A)	**CO131**	x	x				x		x	
	CO132	x	x				x		x	
	CO133	x	x						x	x
CHY-424(A)	**CO134**	x	x				x			
	CO135	x					x			
	CO136	x	x				x			x
	CO137	x					x			x
CHY-425(A)	**CO138**	x					x		x	
	CO139		x						x	
	CO140	x	x	x			x			x
	CO141	x	x				x			x
CHY-426(A)	**CO142**	x	x	x			x		x	x
	CO143	x	x							
	CO144	x					x			
	CO145	x	x	x			x		x	
CHY-423(B)	**CO146**	x					x			
	CO147	x					x			x
CHY-424(B)	**CO148**	x					x			
	CO149	x	x				x			x
	CO150	x	x				x			x
	CO151	x	x				x			x
CHY-425(B)	**CO152**	x	x	x						
	CO153	x					x			x
	CO154	x	x							
	CO155	x	x				x			x
	CO156		x							x
	CO157	x					x			
	CO158	x	x				x			
	CO159	x	x				x			
CHY-426(B)	**CO160**	x	x	x			x		x	x
	CO161	x	x							
	CO162	x					x			
	CO163	x	x	x			x		x	
CHY-423(C)	**CO164**	x		x			x			
	CO165	x				x				
	CO166	x		x		x				x
	CO167	x		x						x
	CO168	x								x
	CO169	x								x
CHY-424(C)	**CO170**	x								
	CO171	x	x	x					x	
	CO172	x	x				x			x
	CO173	x				x				x
	CO174	x					x			x

CHY-425(C)	**CO175**	x	x	x						x
	CO176	x		x						
	CO177	x	x	x			x			x
	CO178	x		x						x
CHY-426(C)	**CO179**	x	x	x			x		x	x
	CO180	x	x							
	CO181	x					x			
	CO182	x	x	x			x		x	

M.Sc. CHEMISTRY (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE- CHY 121
Stability, Bonding and Inorganic Reaction Mechanism
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to make the students explain about the various methods of determination of stability constants, to enable the students to learn about kinetics and reaction mechanism of transition metal complexes, and to acquaint the students with the nature of metal-ligand bonding in coordination compounds on the basis of Molecular Orbital Theory.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 121	Stability, Bonding and Inorganic Reaction Mechanism	**The students will be able to-** CO1-determine the stability constants of complexes by various methods. CO2-predict kinetics and mechanism of ligand substitution reactions in transition metal complexes CO3-construct molecular orbital diagrams of complexes using the fundamental knowledge of quantum mechanics	Interactive lectures Discussions Tutorials Quiz Problem solving	Written test Quiz Assignment Semester end examination

CONTENTS

I **Stability of Complex Ions in Solution** **11hrs**
Thermodynamic and kinetic stability, stepwise and overall formation constants, factors affecting stability of complexes. Determination of the stability constants of complexes: pH-metric method, ion exchange method, spectrophotometric method and polarographic method, determination of composition of complexes: Job's method (method of continuous variation), mole ratio method, slope-ratio method.

II **Mechanism of Reactions of Transition Metal Complexes-I** **13 hrs**
Kinetics of substitution reactions in octahedral complexes, acid hydrolysis(S_N1 mechanism), factors affecting acid hydrolysis and base hydrolysis, conjugate base mechanism(S_N1cB mechanism), direct and indirect evidence in favor of conjugate mechanism. Anation reactions: Reactions without metal ligand bond cleavage, Berrys's pseudo rotation mechanism.

Self-Study: Ligand Substitution Reactions: Patterns of reactivity, classification of mechanisms: Associative, dissociative and interchange mechanism of substitution, energy profile of reaction transition states. Inert and labile complexes.

III Mechanism of Reactions of Transition Metal Complexes-II 12 hrs

Trans effect, theories of trans effect and its uses, mechanism of substitution in square planar complexes, factors affecting substitution reactions in square planar complexes, Swain Scott equation, cis-trans isomerization.

Redox Reactions: Classification, mechanism of one electron transfer reaction: outer sphere type reactions, cross reactions and Marcus-Hush theory (qualitative treatment), inner sphere type reactions, two electron transfer reaction (brief idea).

IV Molecular Orbital Theory-I (σ-bonding) 12hrs

Ligand Field Theory: An introduction, molecular orbital diagrams of some simple polyatomic molecules like BeH_2, H_2O, NH_3, Walsh diagrams: LCAO's approximation, σ-only molecular orbital energy levels for octahedral, tetrahedral and square planar complexes.

V Molecular Orbital Theory-II (π-bonding) 12 hrs

Molecular orbital energy levels for octahedral, tetrahedral and square planar complexes containing π-bonds, effect of pi-bonding. Experimental evidences for π-bonding: Crystallography and Infra-red spectroscopy.

Angular Overlap Model: Principles, σ- and π- bonding in octahedral complexes.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Inorganic Chemistry; Fifth Edition; D.F. Shriver and P.W. Atkins; Oxford University Press, New York, 2004.
- Inorganic Chemistry; Seventh International Edition; M. Weller, T. Overton, J. Rourke, F. Armstrong; Oxford University Press, New York, 2018.
- Inorganic Chemistry (Principle and Structure and Reactivity); Fourth Edition; J. E Huheey, E. A. Keiter, R. L. Keiter; Pearson India, New Delhi, 2013
- Advanced Inorganic Chemistry, Sixth Edition; F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann; John Wiley and Sons, USA, New York, 2007.
- Inorganic Chemistry; Fifth Edition; Gary L. Miessler and Donald A. Tarr; Pearson Education Inc. Singapore, 2013.
- Fundamental Concepts of Inorganic Chemistry; Volume 4 &5, First Edition; A. K. Das and M. Das; CBS Publishers, New Delhi,2014.

PAPER CODE- CHY 122
Structure, Reactivity and Stereochemistry of Organic Compounds
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :

The course aims to make the students understand the core concepts of organic chemistry i.e. resonance, hyperconjugation, inductive effect etc. and their qualitative and quantitative treatment. The course will also provide an in-depth knowledge about the organic-chemical reactions with a focus on aromaticity, stereochemistry, reactive intermediates and their rearrangements.

Course Outcomes (Cos):

COURSE		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 122	Structure, Reactivity and Stereochemistry of Organic Compounds	**The students will be able to-** CO4- identify the different aromatic, non-aromatic, homoaromatic & antiaromatic compounds and interpret their properties. CO5- evaluate the stability of various acyclic and cyclic systems using steric, electronic and stereoelectronic effects and correlate them to reactivity. CO6- describe various types of reactive intermediates and factors affecting their stability . CO7- practice the use of intermediate in skeletal and molecular arrangement CO8- identify and differentiate prochirality and chirality at centers, axis, planes and helices and determine the absolute configuration. CO9- apply various rules for determining stereoselectivity of various organic transformations	Interactive lectures Discussions Tutorials Quiz Problem solving	Written test Google quiz Assignment Tutorial Group activity Semester end examination

CONTENTS

I Aromaticity 12hrs

Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule and Möbius system, energy level of π molecular orbitals in three to eight membered monocyclic systems having conjugation. Annulenes, fullerenes, antiaromaticity, homoaromaticity, PMO approach, steric inhibition to resonance.

Bonds weaker than covalent: Addition compounds, phase transfer catalysis and crown ethers, cryptands, inclusion compounds, cyclodextrins, catenanes, rotaxanes and Kekulene. H-bonding and its effect on organic compounds.

II Structure and Reactivity 12hrs

A review of types of mechanisms and reactions: Methods of determining reaction mechanism, thermodynamic and kinetic control of reactions, Hammond's postulate, Curtin- Hammett principle, isotope effects.

Effect of structure on reactivity, resonance effect, field effects & steric effects. Quantitative treatment of the effect of structure on reactivity. The Hammet equation and linear free energy relationship, substituent and reaction constants & Taft equation.

Applications of HSAB principle to organic reactions.

III Study of Reactive Intermediates 12hrs

Types, generation, structure, stability, detection and reactivity of the reactive intermediates-carbocation including non-classical carbocation, carbanion, free radical, radical anion, carbene, nitrene, benzyne, nitrenium ion. Electrophiles and nucleophiles. Molecular rearrangements involving above intermediates viz. Wagner - Meerwein, Pinacol-Semipinacol, Benzil-Benzilic acid, Hoffmann, Curtius, Lossen, Schmidt, Beckmann, Naber, Favorskii, Wittig, Riemer–Tiemann reaction. Dissolving metal reduction.

IV Stereochemistry – I 12hrs

Chirality and asymmetry, molecules with one, two or more chiral centres. Configuration nomenclature, D/L and R/S types of recemates and methods of resolution.

Prochirality: Topicity of ligands and faces and their nomenclature. Stereogenicity, pseudoasymmetry, planar chirality, axial chirality, optical purity, chirogenicity, stereogenic and prochiral centres.

Optical activity in the absence of chiral carbons: biphenyls, allenes, alkyldienes, cycloalkyldienes, spiranes, ansacompounds, adamantanes, and cyclophanes, chirality due to helical shape (P & M), chirality in the compounds containing N, S and P.

V Stereochemistry – II 12hrs

Configurations, conformations and stability of cyclohexanes (mono-, di-, and trisubstituted), cyclohexenes, cyclohexanones, halocyclohexanones, decalins, decalols and decalones, effect of conformation on reactivity, strain in cycloalkanes.

Chiral synthesis, stereoselective and stereospecific synthesis, Prelog's rule, Felkin-anh rule, CD, ORD, octant rule, Cotton effect and their application in determination of absolute and relative configuration and conformation, the axial haloketone rule. Chiral auxiliary and chiral pool.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Advanced Organic Chemistry: Reactions, Mechanisms and Structure; Seventh Edition; J. March; John Wiley and Sons Asia Private Limited, New Delhi, 2015.
- Advanced Organic Chemistry Part A & B; Fifth Edition; F. A. Carey and R. J. Sundberg; Springer, US, 2007.
- Stereochemistry: Conformation and Mechanism; Tenth Edition; P.S. Kalsi; New Age International Publishers Pvt. Ltd, New Delhi, 2019.
- Physical Organic Chemistry Vol. I and II; Second Edition; N. Isaacs; Longman Scientific and Technical,1995.
- Named Organic Reactions; Second Edition: T. Lave and A. Plagens; John Wiley and Sons, 2005.
- Organic Chemistry: Vol. I and II; Singh, Mukherjee, Kapoor; Second Edition; New Age International Private Limited, New Delhi, 2018.
- Organic Reaction Mechanism; Fourth Edition; V.K. Ahluwalia and R.K. Parashar; Narosa Publishing House, New Delhi, 2002.
- Stereochemistry of Organic Compounds; Third Edition; D. Nasipuri; New Age International Publishers Pvt. Ltd, New Delhi, 2007.
- Stereochemistry and Mechanism through solved Problems; Third Edition; P. S. Kalsi; New Age International Pvt. Ltd., New Delhi, 2004.

PAPER CODE- CHY 123
Quantum Chemistry and Group Theory
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to give the knowledge of principles of quantum mechanics so that the students will be able to apply quantum mechanical principles to solve simple systems. To make students aware of symmetry and group theory so that they will be able to use group theory as a tool to understand bonding.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 123	Quantum Chemistry and Group Theory	**The students will be able to-** CO10-reproduce the concepts of quantum mechanics and solve simple systems using Schrodinger wave equation. CO11-calculate physical properties for simple systems. CO12-interpret and apply approximate methods for evaluating wavefunction. CO13-describe quantum mechanical approach of angular momentum, spin and rules for quantization and evaluate expressions for it. CO14-discuss bonding in diatomic, triatomic and systems containing double bonds using molecular Orbital theory. CO15-recognize symmetry elements, symmetry operations, point group in a molecule and construct character table for different point groups. CO16-reproduce the concept of symmetry adapted linear combinations and apply it for understanding bonding in simple (σ and π) as well as conjugated systems.	Interactive lectures Discussion Tutorials Reading assignments Demonstration Interactive quiz	Assignments Written test Tutorials Google quiz Semester end examination

CONTENTS

I Introduction to Quantum Mechanical Results 16 hrs
Schrodinger equation, postulates of quantum mechanics, operators, Hamiltonian and Hermitian operator, discussion of solutions of the Schrodinger equation of some model systems: Particle in a box and its extension to 3D box, quantization of energy levels, degeneracy, zero point

energy and justification for Heisenberg uncertainty principle, simple harmonic oscillator and its solution using series solution or factorization method, calculation of various average values using ladder operator and recursion relation of Hermite polynomial, rigid rotor, hydrogen atom, radial distribution function of 1s, 2s, 2p, 3s, 3p and 3d orbitals and polar plots, node, nodal plane and nodal sphere.

II Approximate Methods and Angular Momentum 11 hrs

The variation theorem, linear variation principle, perturbation theory (first order and non – degenerate), application of variation method and perturbation theory to helium atom. Ordinary and generalized angular momentum, eigen functions and eigen values for angular momentum operator using ladder operators, spin, antisymmetry and Pauli's exclusion principle.

III Molecular Orbital Theory 8 hrs

Extension of MO theory to homonuclear and heteronuclear diatomic molecules, qualitative MO theory and its applications to AH_2 type molecule, Huckel theory of conjugate systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclobutadiene, benzene, allyl system and cyclopropenyl system. Introduction to extended Huckel theory.

IV Symmetry and Group Theory 14 hrs

Symmetry elements and symmetry operations, definition of group and subgroup, conjugacy relation and classes, product of symmetry operations, relation between symmetry elements and symmetry operations, orders of a finite group and its subgroup, point group symmetry, schonfiles symbols, representations of groups by reducible and irreducible representations and relation between them (representation for the C_n, C_{nv}, D_{nh} etc. groups to be worked out explicitly), character of a representation, the great orthogonality theorem (without proof) and its importance, character tables of C_{2v} and C_{3v} and their use.

V Applications of Group Theory in Chemistry 11 hrs

Formation of hybrid orbitals: Sigma bonding in linear structure ($BeCl_2$), trigonal planar (BF_3), tetrahedral (CH_4), square pyramid (BrF_5) and square planar (XeF_4), octahedral and square planar complexes, π bonding in complex compounds: square planar molecule and tetrahedral molecule.

Molecules with delocalized π orbitals, cyclopropenyl system, cyclobutenyl system, cyclopentadienyl system and benzene.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Quantum Chemistry; Seventh Edition; I. N. Levine; Pearson Education India, New Delhi, 2016.
- Introductory Quantum Chemistry; Fourth Edition; A.K. Chandra; Tata McGraw Hill Publishing Company, New Delhi, 2017.
- Quantum Chemistry Including Molecular Spectroscopy; B.K. Sen; Tata McGraw Hill Publishing Company, New Delhi, 1996.
- Quantum Chemistry; Fourth Revised Edition; R.K. Prasad; New Age International (P) Ltd, New Delhi, 2009.
- Molecular Quantum Mechanics; Fifth Edition; P.W. Atkins and R.S. Friedman; Oxford University Press Club, New York, 2012.
- Chemical Applications of Group Theory; Student Third Edition, F. A. Cotton; Wiley-India(P) Ltd, New Delhi, 2008.
- Chemical Applications of Group Theory; Third Edition, F. A. Cotton; John Wiley and Sons, Singapore 2008.
- Symmetry and Group Theory in Chemistry; Second Edition, S. K. Dogra and H. S. Randhawa; New Academic Science, 2017.
- Group theory and its Chemical Applications; P. K. Bhattacharya, Himalaya Publishing House, 2014.

- Symmetry and Spectroscopy of Molecules; RevisedSecond Edition; K. Veera Reddy; New Age Publishers, New Delhi, 2009.

PAPER CODE- CHY 124
Principles of Spectroscopy
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to impart knowledge of origin of basic principles of spectroscopy and its applications to rotational, vibrational, Raman, electronic and NMR spectroscopy.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 124	Principles of Spectroscopy	**The students will be able to-** CO18- describe working principle and selection rule of rotational, vibrational, Raman and electronic spectroscopy. CO19- distinguish between various spectroscopic transitions and interpret data for molecular characterization. CO20- apply quantum mechanical approach to NMR spectra (A2, AB and AX system).	Class lectures Discussions Demonstrations Tutorials Interactive quiz	Written test Viva voce Quiz Semester end examination

CONTENTS

I **Basic Elements of Spectroscopy** **8 hrs**
Uncertainty relation and natural line width, natural line broadening, doppler line broadening, pressure broadening, saturation broadening, removal of line broadening. signal-to-noise ratio, resolving power, intensity of spectral lines – transition probability, population of states, path length of sample. General components of an absorption experiment in various regions, dispersing elements, basic elements of practical spectroscopy, Born-Oppenheimer approximation: Rotational, vibrational and electronic energy levels in molecules, selection rules and their derivations, Fourier Transform methods (IR and NMR).

II **Rotational Spectroscopy** **8 hrs**
Classification of molecules, linear triatomic molecule, intensities, energy levels and rotational spectra of symmetric top molecules, Stark effect, nuclear and electron spin interaction, effect of external field, applications.

III Vibrational Spectroscopy 18hrs

Vibrational energies of diatomic molecule, anharmonicity, vibrational-rotational spectroscopy, P, Q, R branches, breakdown of Born-Oppenheimer approximation, selection rules, vibrations of poly atomic molecules, normal mode of vibrations, skeletal vibrations, group frequencies, overtones, hot bands, fermi resonance bands, factors affecting the band positions and intensities.

Raman spectroscopy: Classical and quantum theories of Raman effect, molecular polarizability, selection rules, rotational Raman spectra-linear molecules, symmetric top and spherical top molecules, vibrational Raman spectra and rotational-vibrational Raman spectra of diatomic molecule, mutual exclusion principle, polarized and depolarized Raman spectra.

Resonance Raman Spectroscopy, Coherent Antistokes Raman Spectroscopy CARS (an elementary idea)

IV Electronic Spectroscopy 14 hrs

Atomic spectroscopy: Energy of atomic orbitals, vector representation of momenta and vector coupling (orbital and spin coupling), term symbols, spectra of hydrogen atom, alkali metal atoms, helium, alkaline earth metals and polyelectronic atoms.

Molecular spectroscopy: Energy levels, molecular orbitals- homonuclear and heteronuclear diatomic molecules, vibronic transitions, progression and sequences, derivation of Franck-Condon principle, dissociation and pre-dissociation. Electronic spectra of polyatomic molecules: AH_2 type molecules, formaldehyde and benzene. Emission spectra, radiative and non-radiative decay, internal conversion.

V NMR Spectroscopy 12 hrs

Larmor precession, mechanism of spin-spin and spin-lattice relaxations and quantitative treatment of relaxations, quantum mechanical treatment of A_2 system, AB system and AX system, selection rules and relative intensities of lines.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Fundamentals of Molecular Spectroscopy; Fourth Edition; C. N. Banwell and E. M. Mc Cash; Tata McGraw Hill, New Delhi, 2017.
- Modern Spectroscopy; Fourth Edition; J.M. Hollas; John Wiley and Sons, India, 2004.
- Introduction to Molecular Spectroscopy; International Edition; G.M. Barrow; Tata McGraw- Hill, Singapore, 1999.
- Physical Methods in Inorganic Chemistry; First Edition; R. S. Drago; Affiliated East-West Press Pvt. Ltd., New Delhi, 2012.
- Analytical Chemistry – Theory and Practice; Third Edition; U. N Dash; S. Chand and Co., New Delhi, 2019.
- Atomic and Molecular spectroscopy; First Edition; S.K. Dogra and H.S. Randhawa; Pearson Education, 2015.
- Atom, Molecule and Spectrum; S.K. Dogra and H.S. Randhawa; New Age International (P) Limited, 2015.
- NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry; Third Edition; H. Gunther; Wiley-VCH, 2013.
- Molecular Structure and Spectroscopy; Second Edition; G. Aruldhas; PHI Learning Private Limited, 2015.

PAPER CODE- CHY 125 (A)
Mathematics for Chemists
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :
The course aims to acquaint the students with the fundamentals of analytical mathematics and their use in some important applications of chemistry (e.g. Huckel theory, maximally populated rotational energy levels and Bohr's radius). This course also aims to make the students aware about the concept of matrix properties, calculus, probability and elementary differential equation (first order & first degree).

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 125(A)	Mathematics for Chemists	**The students will be able to-** CO21-employ basic operations like addition, multiplication, transpose, inverse and determinant of matrices. CO22-differentiate one variable function up to a higher order, two variable functions up to second order. CO23-apply the basic rules of integration on one variable function and product of one variable functions. CO24-analyze the simple problems of permutation, combination and probability and concept of scalers and vectors and their operations. CO25-distinguish between the concept of order and degree of differential equation and solution of first order and first degree linear differential equation.	Traditional chalk & board method Group discussions Tutorials Quiz Problem solving Question preparation- Subjective type- Long answer & Short answer Objective type- Multiple choice questions, One answer/two answer type questions Assertion and reasoning	Group/ Individual Presentations Written Test Assignment Semester end examination

CONTENTS

I Matrix Algebra **6 hrs**
Matrix properties: Matrix addition and multiplication, adjoint, transpose and inverse of matrices, special matrices (symmetric, skew-symmetric, unit, diagonal), determinants (examples from Huckel theory).

II Differential Calculus **6 hrs**
Rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most

probable velocity from Maxwell's distribution etc.), partial differentiation, co-ordinate transformations.

III Integral Calculus 6 hrs

Integral Calculus: Basic rules for integration, integration by substitution, integration by parts and through partial fraction.

IV Permutation, Probability, Vector Algebra and Calculus 6 hrs

Permutation and Probability: Permutations and combinations, probability and probability theorems, curve-fitting (including least squares fit etc.) with a general polynomial fit.

Scalars and vectors, addition, subtraction and multiplication of vectors. Vector operators: Gradient, divergence and curl. (Expressions only).

V Elementary Differential Equations 6 hrs

Order and degree of differential equation solution of first order and first degree linear differential equation by variable-separable, homogenous and linear equations, applications to chemical kinetics, secular equilibria, quantum chemistry etc.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- The Chemistry Maths Book; Second Edition; E. Steiner; Oxford University Press, Gwalior: Oxford Public School, 2008.
- Basic Mathematics for Chemists; Second Edition; P. Tebbutt; John Wiley and Sons, 2001.
- Mathematical Methods in the Physical Sciences, M. L. Boas; John Wiley & Sons, 2006
- Maths for Chemists; Second Edition; G. Doggett and M. Cockett; Royal Society of Chemistry,2012.

PAPER CODE- CHY 125 (B)
Introduction to Biomolecules
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :

The course aims to enable the learners to understand the basic processes which link the biological systems with the chemical systems and to provide them with the basic knowledge and insight about the three-dimensional (3D) structure of macromolecules (protein and nucleic acids) and the relationship between their structure and function.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 125(B)	Introduction to Biomolecules	**The students will be able to-** CO26-describe the function of several important proteins and relate their function to the structure. CO27-identify the chemical elements of carbohydrates and the difference between simple sugars and complex carbohydrates. CO28-understand the relationship between cellular activities and biological responses. CO29-gain the knowledge of cell metabolism, chemical composition, physiochemical and functional organization of organelles CO30-understand the different composition and roles of nucleic acids in the cell and their interactions with each other. CO31-acquire perspectives on contemporary approaches and techniques used in modern cell and molecular biology.	Interactive lectures Discussions Tutorials Quiz	Written test Google quiz Assignment Semester end examination

CONTENTS

I Concept of Cell 6 hrs

Origin of Life: prokaryotes and eukaryotes, difference between plant and animal cell, hierarchy of molecular organization of living systems.
A brief concept of cell organelles and their functions: nucleus, plasma membrane, chloroplast, Golgi bodies, endoplasmic reticulum, lysosomes, ribosomes and mitochondria: ATP Synthesis (substrate level phosphorylation like glycolysis and Kreb's cycle and oxidative level phosphorylation).

II Amino Acids & Proteins 9 hrs

Introduction, classification, optical isomerism, chemical properties, acid-base properties-peptide bond formation and properties. Protein structure: Primary, secondary, tertiary & quaternary structures, denaturation of proteins, Ramachandran plot. Determination of Primary Structure - sequencing strategies, N-terminal and C-terminal sequencing.

Synthesis of amino acids by reductive amination, GS-GOGAT system and transamination.
Enzymes: Introduction, classification of enzymes, mechanism of enzyme action, enzyme kinetics, Michaelis – Menten equation and enzyme inhibition.

III Carbohydrates 4 hrs

Classification, structure and functions of monosaccharides, disaccharides, polysaccharides: starch, cellulose, glycogen, chitin and pectins.
Glycoconjugates: Proteoglycans, glycoproteins and glycolipids.

IV Lipids 5 hrs

Structure, sources, nomenclature and functions of lipids, saturated and unsaturated fatty acids, classification: Simple, compound and derived lipids (steroids and cholesterol). Synthesis of long chain fatty acids, α-oxidation, β-oxidation.

V Nucleic Acids 6 hrs

Purines and Pyrimidines: Structures of purine and pyrimidine bases, nucleosides and nucleotides.
DNA: Double helical structure of DNA(Watson and Crick model) , types of DNA -A, B, C and Z forms, replication.
RNA: RNA structure and its types- rRNA, mRNA, and tRNA, ribozymes. Differences between DNA & RNA

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Lehninger Principles of Biochemistry International Edition; Seventh Edition; David L. Nelson and Michael Cox; W.H. Freeman, 2017.
- Biochemistry; Ninth Edition; L. Stryer; W.H. Freeman and Company, 2019
- Biochemistry; First Indian Reprint; J. D. Rawn; Tanima Publishing Corporation, New Delhi, 2004.
- Biochemistry; Fourth Edition; D. Voet; John Wiley and Sons, 2011.
- Outline of Biochemistry; Fifth Edition; E.E. Conn and P.K. Stumpf; John Wiley and Sons Inc., New Delhi, 2006.

PAPER CODE- CHY 126
Inorganic Chemistry Lab I
(Practical)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives :
The course aims to acquaint the students with various safety measures including handling of chemicals, safe disposal of chemical wastes etc., to make students understand the concept of separation of mixtures containing metal ions, insolubles and interfering radicals and to make students learn about the quantitative estimation of different ions volumetrically.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 126	Inorganic Chemistry Lab I	**The students will be able to-** CO32- apply the knowledge of lab safety measures during the experimental work. CO33- analyze and detect ions, rare elements and other pollutants in the samples of daily use (vegetables, food, water etc.) CO34- estimate the concentrations of different ions volumetrically.	Discussions Demonstrations Problem solving	Practical Performance Written Test Quiz Viva Voce Semester end examination(Practical as well as written test) followed by Viva-voce)

CONTENTS

Laboratory Safety Measures

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, safe storage and use of hazardous chemicals. Procedure for working with gases above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, neutralization of strong acids and strong bases, procedure for laboratory disposal of explosives.

Qualitative Mixture Analysis

Analysis of mixture for eight radicals (cations and anions) including

i. Less common metal ions – Mo, W, Ti, Zr, Th, V, U (two metal ions in cationic/anionic forms).
ii. Insolubles – oxides, sulphates and halides.
iii. Interfering- oxalate, phosphate, borate, fluoride.

Quantitative Analysis: Volumetric Analysis (any three)

i. Determination of Chloride ion in water by Mohr's method or by use of adsorption indicator.
ii. Determination of Nickel using Eriochrome Black T as an indicator (Back titration).

iii. Determination of percentage purity of boric acid.
iv. Determination of Nitrite in a given sample.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Vogel's Qualitative Inorganic Analysis; Seventh Edition; G. Svelha, B. Sivasankar; Pearson Education India,2012
- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Advanced Practical Chemistry; First Edition; S. C. Das; Calcutta Publishing, Calcutta, 2000.

PAPER CODE- CHY 127
Organic Chemistry Lab I
(Practical)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives :
The programme aims at providing ample training in handling basic chemical laboratory instruments, develop quantitative and qualitative skills and useful techniques.

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 127	Organic Chemistry Lab I	**The students will be able to-** CO35-work safely in a chemistry lab and know what to do in case of an accident CO36-apply suitable techniques to separate an organic mixture. CO37- perform both independently and be able to document the results obtained through the writing of lab reports. CO38-develop competence in intellectual, practical and transferable skills necessary for employment as a professional chemist.	Demonstration Interactive lectures Problem solving	Practical performance Written test Quiz Viva voce Semester end examination (Practical as well as written test followed by Viva-voce)

CONTENTS

Laboratory Safety Measures

MSDS, identification, verification and segregation of laboratory waste, disposal of waste in sanitary sewer system, incineration and transportation of hazardous chemicals. Flammable solvents, fire hazards in chemical laboratory.

Basic Techniques Involved in Synthetic Organic Chemistry

- Different types of glasswares.
- Filtration.
- Distillation (distillation at atmospheric pressure, steam distillation, fractional distillation and distillation at reduced pressure).
- Recrystallization and melting point correction.
- Use of decolorizing carbon.
- Thin layer chromatography.

Qualitative Analysis

Separation, purification and identification of components of a mixture of two organic compounds (one liquid and one solid or two solids) using TLC for checking the purity of separated compounds.

Quantitative Analysis

- Determination of the percentage and number of hydroxyl groups in an organic compound by acetylation method.

- Estimation of amines/phenols using bromate bromide solution.
- Determination of iodine number and saponification value of an oil sample.

Demonstration Exercise

- Estimation of sulphur by messenger or fusion method.
- Estimation of nitrogen by Kjeldahl's method.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition; B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell ; Adission – Wesley Longman Ltd. England, 2015.
- Practical Organic Chemistry; Fourth Edition; F.C. Mann, B.C. Saunders; Pearson Education Ltd., New Delhi, 2013.
- Advanced Practical Organic Chemistry; J. Leonard, B. Lygo and G. Procter; Third Edition; CRC Press,2013.

PAPER CODE- CHY 128
Communication Skill: Seminar
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :
The course aims to enable the students to demonstrate a clear and exhaustive understanding of the basic concepts of grammar with a special focus on technical communication and subject-specific skills. It also ensures the enhancement of their ability to read, assimilate and discuss scholarly articles and research papers showcasing chemistry as well as the interdisciplinary areas of sciences and to develop strong oral and written communication skills to present their ideas effectively through power-point presentations and appropriate software for the analysis of data.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 128	Communication Skill: Seminar	**The students will be able to-** CO39-read and emulate the documents with in-depth analyses and logical arguments which further enhances their interaction with both specialized and non-specialized audiences on a specific idea or concept. CO40-apply the latest subject matter, both theoretical as well as practical, in a way to foster their core competency and discover true learning. CO41-examine specific phenomena theoretically and/or experimentally to contribute to the generation of new scientific insights or the innovation of new applications of research in Chemistry. CO42-identify their domain-independent knowledge with a focus on critical thinking and communication.	Self-motivated learning Literature review Group discussions Report witting	Power point presentation by individual student Mock interview Viva-voce Group discussions

CONTENTS

I **Grammar** **6 hrs**
Conditionals/Tenses
Relative Clauses
Subject – Verb Agreement
Passive Voice

II Written Communication 6 hrs

Discuss a topic of general interest but related to science in about 300 words.
(Analyse, Comment, Argue, Reflect, Persuade, etc.)
(can also be used for oral presentations by the students, followed by discussion).

III Scientific Report Writing 5 hrs

Writing a Scientific Report on a project undertaken or an experiment conducted (Theory + Practice).

IV Oral Communication I 3hrs

a) Consulting a dictionary for correct pronunciation (familiarity with Phonetics Symbols and Stress-marks only).
b) Dialogue.

V Soft Skills 10hrs

1. **Gestures/ Postures** – Body language, gesture, posture.
2. **Group Discussion** – Giving up of PREP, REP Technique, how body language during group discussion.
3. **Presentation Skills**
   a) How to make power point presentation.
   b) Body language during presentation.
4. **Resume Writing**
   a) Cover letter, career objective.
   b) Resume writing (tailor made).
5. **Mock Interview**
   Each student to face an interview and to demonstrate the above taught skills.
6. **Positive Attitude**
   Positive skills enhancement with power point presentation.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Advanced English Usage; Quirk & Greenbaum; Pearson Education.
- Developing Communication Skills; Second Edition; M. Banerjee &K. Mohan; Macmillan Publications, 1996.
- Business Communication: Concepts, Cases and Applications; P.D. Chaturvedi; Pearson Publications, 2008.
- Business Communication: Process and Skills; M.J. Mathew; RBSA Publications, 2016.
- Communication of Business: A Practical Approach; Fourth Edition; S. Taylor; Pearson Publications, 2011.
- Soft Skills : ICFAI Publication
- Dictionary Oxford Publication.

COURSE OUTCOMES- Semester II
PAPER CODE- CHY 221
Spectroscopy
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to endow the students with the concepts of various spectroscopic techniques for the structural elucidation of inorganic molecules and complexes.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 221	Spectroscopy	**The students will be able to-** CO43-determine the structures of simple inorganic molecules using the concepts of IR and Raman spectroscopy CO44-apply the knowledge of group theory in differentiating between geometrical as well as linkage isomers CO45-use the fundamentals of NQR spectroscopy in interpreting the structures of crystalline molecules CO46-interpret the photoelectron spectra of various atoms and molecules CO47-calculate number of microstates and determine different spectroscopic states CO48-draw Orgel, Tanabe-Sugano and Correlation diagrams of complexes CO49-discuss ESR and its applications in transition metal complexes including biological systems CO50-apply the knowledge of Mossbauer spectroscopy in structural determination of iron and tin compounds	Interactive lectures Group discussions Tutorials Quiz Problem solving sessions	Group discussion Google quiz Written test Tutorials Assignment Semester end examination

CONTENTS

I IR, Raman and NQR Spectroscopy 16 hrs

Some important aspects of IR and Raman spectra: Classification of normal modes of molecular vibrations and IR and Raman active modes in some simple molecules. Characteristic group vibrations.

Electronic and coupling effect on group vibration frequency. Application of IR and Raman spectra: Determination of structure of some simple molecules(CO_2,SO_2,N_2O), determination of structure of H_2O and NH_3 through the normal modes of analysis, effect of coordination of ligands on vibrational spectra, determination of geometrical isomers of coordination compounds, identification of linkage isomers.

Nuclear Quadrupole Resonance Spectroscopy: Introduction, basic principles of NQR spectroscopy, NQR transition energies for the axially and non-axially symmetric systems, effect of a magnetic field (Zeeman effect) on NQR transitions, conditions to observe the NQR signals (in brief). Applications: Interpretation of eQq data, effect of crystal lattice on the magnitude of eQq, structural information from NQR spectra.

II Electronic Spectroscopy 15 hrs

Coupling scheme (orbit-orbit, spin-spin and spin orbit coupling, determination of ground state, spectroscopic ground states, selection rules for electronic transitions, splitting of d^n terms in octahedral and tetrahedral field. Correlation diagrams, Orgel and Tanabe-Sugano diagrams (d^1-d^9 states), spin cross-over; Field strength, nephelauxetic series, calculations of Racah parameters (B and C). Applications of Tanabe-Sugano diagrams in determining $\triangle_o$ from spectra. Charge transfer spectra and its application in inorganic & coordination compounds.

III Photoelectron Spectroscopy 10 hrs

Basic principle, ionization process, Koopman's theorem, photoelectron spectra of atoms (Ar, Kr, Xe) and simple molecules (H_2, N_2, CO, NO, HBr, C_6H_6), ESCA and its applications, Auger electron spectroscopy (basic idea)

IV Electron Spin Resonance Spectroscopy 11 hrs

Some basic elements of ESR spectroscopy, relaxation processes: Spin-lattice relaxation, spin-spin relaxation and exchange interaction. Zero field splitting and Kramer's degeneracy, 'g' value and factors affecting ESR lines, Hyperfine interaction: Isotropic and anisotropic hyperfine interaction, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, application to transition metal complexes (having one unpaired electron) including biological systems.

V Mossbauer Spectroscopy 8 hrs

Principles of Mossbauer(MB) spectroscopy, isomeric shift in MB spectroscopy, Quadrupole interaction and splitting of the MB spectral lines, effect of a magnetic field on the MB spectrum, magnetic hyperfine interaction, application of technique to the studies of bonding and structure determination of Fe^{+2}, Fe^{+3}, Sn^{+2} and Sn^{+4} compounds.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Fundamental Concepts of Inorganic Chemistry; Volume 4 and 7; First Edition; A. K. Das and M. Das; CBS Consumer Publishing, New Delhi, 2014.
- Fundamentals of Molecular Spectroscopy, Fourth Edition.; C.N. Banwell & Mc Cash.; Tata McGraw-Hill, New Delhi, 2017.
- Modern Spectroscopy; Fourth Edition; J.M. Hollas; John Wiley and SonsLtd, England,2004
- Physical Methods in Inorganic Chemistry, R.S. Drago; East-West Press Pvt.Ltd., New Delhi, 2012.
- Inorganic Electronic Spectroscopy; Second Edition; A.B.P. Lever; Elsevier Science Publishing Company Inc., New York, 1986.

- Analytical Chemistry – Theory and Practice; First Edition; U. N Dash; Prentice Hall India Learning Private Limited, New Delhi, 2010.

PAPER CODE- CHY 222
Mechanism of Organic Reactions
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to provide students with an in-depth knowledge of different types of reaction mechanisms i.e. substitution, elimination and addition reactions of aliphatic and aromatic organic compounds.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 222	Mechanism of Organic Reactions	**The students will be able to-** CO51-learn the mechanistic and stereochemical aspects of the substitution, elimination and addition reaction of aliphatic and aromatic organic compounds. CO52- account for the formation of specific products in an organic reaction CO53-differentiate kinetically and thermodynamically controlled reaction. CO54-demonstrate basic knowledge of frontier molecular orbital theory in organic reactions and of the HSAB principle. CO55-illustrate the mechanistic concepts to specific name reactions CO56-apply the basic principles involved in C-C and C-hetero multiple bond formation and be able to illustrate specific name reactions using these principles	Interactive lectures Discussion Tutorials Assignments Power Point presentation	Written Test Quiz Assignment Tutorial Group Activity Semester end examination

CONTENTS

I Substitution and Elimination 16 hrs

Aliphatic Nucleophilic Substitution: S_N1, S_N2, mixed S_N1 and S_N2, ion pair and S_N1 mechanism, SN_i mechanism, neighbouring group participation; Substitution at allylic and vinylic carbon atoms, ambident nucleophiles, effect of substrate structure, nucleophile, leaving group, reaction medium on the reactivity. Regioselectivity.

Elimination Reactions: E2, E1, E1CB and E2C (syn elimination) mechanisms, E1 – E2 – E1CB spectrum, orientation of the double bond, effect of substrate structure, attacking base, leaving group and reaction medium on reactivity. Mechanism and orientation in pyrolytic elimination.

II Aromatic Substitution 16hrs

(a) Aromatic Nucleophilic Substitution**:** S_NAr, benzyne and $S_{RN}1$ mechanism, effect of substrate structure, leaving group and attacking nucleophiles on reactivity. Typical reactions– Bucherer reaction, Rosenmund-von Braun reaction, Von-Richter, Sommelet-Hauser and Smiles rearrangement.

(b)Aromatic Electrophilic Substitution: Arenium ion mechanism, orientation and reactivity, energy profile diagrams. Directive influence and its explanation in different substitutions. o/p ratio, ipso attack, substitution reactions involving diazonium ions, Vilsmeir-Haack reaction., Friedel-Craft reaction: Alkylation, arylation (Scholl reaction), acylation (ring closer, Haworth reaction, Hoesch reaction).

III Aliphatic Electrophilic Substitution & Free Radical Substitution Reactions 10hrs

Aliphatic Electrophilic Substitution: Bimolecular mechanism– S_E2 and S_Ei, the S_E1 mechanism, substitution accompanied by double bond shifts, halogenation, sulphonation, aliphatic diazonium coupling, direct amination, metalation with organometallic compounds, trans metalation with metal and metal halides, insertion by nitrenes, insertion by carbenes, acylation at an aliphatic carbon. Effect of substrates, leaving group and solvent polarity on the reactivity. Free radical substitution mechanisms, mechanism at an aromatic substrate, neighbouring group participation and free radical rearrangements, reactivity for aliphatic and aromatic substrates, reactivity at bridgehead, reactivity of the attacking radical and effect of solvent on reactivity. Important reactions involving free radicals: Sandmeyer and Gattermann reaction, Hunsdiecker reaction, Gomberg-Bachmann reaction, coupling of alkynes.

IV Addition to C-C and C-Hetero Multiple Bonds 9hrs

Addition to C-C multiple bond: Mechanistic and stereochemical aspects of addition reaction involving electrophiles, nucleophiles and free radical, regio and chemo selectivity, orientation and reactivity, addition to cyclopropane ring, hydrogenation of aromatic rings.

Addition to C-Hetero Multiple Bonds: Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles, addition of Grignard reagents, organozinc, organocopper and organolithium reagents to carbonyl and unsaturated carbonyl systems.

V Enolate Chemistry 9hrs

Formation of enolates, kinetic and thermodynamic control, 1,2 *vs* 1,4 addition, HSAB principle, reactions of enolate anions with electrophiles: O and C alkylation. Enolate condensation reactions: Synthetic applications of inter and intramolecular Aldol condensations, Claisen, Dieckmann, Knoevenagel, Stobbe's condensations. Stereoselective enolate reactions: Diastereoselection, Zimmermann-Traxler model, Evans mode. Baylis-Hillmann reaction, Robinson annulation.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Advanced Organic Chemistry: Reactions, Mechanisms and Structure; Seventh Edition; J. March; John Wiley and Sons Asia Private Limited, New Delhi, 2015.
- Advanced Organic Chemistry Part A & B; Fifth Edition; F. A. Carey and R. J. Sundberg; Springer, US, 2007.
- Principles of Organic Synthesis; Third Edition; R.O.C. Norman and J.M. Coxon; Chapman and Hall Ltd., London, 2003.
- A Guidebook to Mechanism in Organic Chemistry; Sixth Edition; P. Sykes; Pearson Education, Delhi, 2011.
- Supplement for Basic Principles of Organic Chemistry; First Edition; J. D. Roberts and M. C. Caserio; W. A. Benzamin Inc., New York, 1965.

- Organic Chemistry: Vol. I and II; Singh, Mukherjee, Kapoor; Second Edition; New Age International Private Limited, New Delhi, 2018.

PAPER CODE- CHY 223
Thermodynamics and Surface Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to acquaint the students with the fundamentals of statistical thermodynamics and its applications in calculating thermodynamic properties. To make the students aware of thermodynamics of irreversible system, advanced aspects of colloidal and surface phenomena.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 223	Thermodynamics and Surface Chemistry	**The students will be able to-** CO57-determine partial molar properties and can explain the concept of excess functions for non-ideal solutions. CO58- recognize suitable statistics for a particular system. CO59-describe the concept of partition functions and calculate thermodynamic properties in terms of partition function. CO60- explain the statistical approach to entropy. CO61- explain the concept and theory of thermodynamics for non-equilibrium systems. CO62-analyze and quantitatively determine interfacial phenomena and behavior of colloidal systems	Interactive lectures Discussion Tutorials Multimedia presentations Assignments	Individual/Group presentation Google quiz Tutorials Assignment Semester end examination

CONTENTS

I Classical Thermodynamics **10 hrs**

Thermodynamics of open system: Partial molar properties, determination of these quantities and their significance, chemical potential in a system of ideal gases, Gibbs- Duhem equation, fugacity and determination of fugacity.
Non-ideal systems: Excess functions for non-ideal solutions, the concept of activity and activity coefficient.

II Introduction to Statistical Thermodynamics **15 hrs**

Quantum mechanical aspects: Concept of distribution, thermodynamic probability and most probable distribution, common terms- occupation number, statistical weight factor, configuration, phase space, macroscopic state, microscopic state, system, assembly, canonical, grand canonical and microcanonical ensemble, ensemble averaging and its postulates.
Type of statistics- Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistics. Applications of statistics to helium, photon gas and metals.

Molecular partition function for an ideal gas, translational, rotational, vibrational, electronic and nuclear partition function.

III Statistical Approach to Thermodynamic Properties and Entropy 15 hrs

Calculation of thermodynamic properties in terms of partition function-

Translational energy, entropy, enthalpy, Helmholtz function, Gibb's free energy of a monoatomic gas. Equilibrium constant, equipartition principle, heat capacity of mono and diatomic gases, mixture of o and p- hydrogen, heat capacity of solids.

Entropy, probability, Boltzmann-Planck equation, significance of thermodynamics probability, entropy of expansion of ideal gas, molecular basis of residual entropy, statistical calculation of entropy, vibrational entropy, nuclear spin entropy, virtual entropy, rotational entropy, comparison of third law and statistical entropies, random orientation in the solids, entropy of hydrogen and deuterium.

IV Non-Equilibrium Thermodynamics 9 hrs

Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (heat flow, chemical reaction etc.), transformations of the generalized fluxes and forces, non-equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomenon, diffusion and electric conduction. Irreversible thermodynamics for biological systems, coupled reactions.

V Surface and Colloidal Phenomena 11 hrs

Adsorption of gases by solids, BET adsorption isotherm, adsorption from solution, Gibbs adsorption isotherm. Surface films on liquids (electrokinetic phenomena), catalytic activity of surfaces.

Surface active agents, classification**,** hydrophobic interaction**,** micelle formation: Mass action model and phase separation model, shape and structure of micelles, micellar aggregation numbers, critical micelle concentration (CMC), factors affecting CMC of surfactants, counter ion binding to micelles, thermodynamics of CMC, thermodynamics of micellization, micelle temperature range (MTR) or Kraft point, solubilization, micro emulsion and reverse micelles.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- An Introduction to Chemical Thermodynamics; Sixth Edition; R.P Rastogi and R.R Misra; Vikas Publishing House, 2018.
- Thermodynamics for students of Chemistry; Third Edition; K. Rajaram and J.C Kuriacose; Shoban Lal & Company, Jalandhar.
- Chemical Thermodynamics; Seventh Edition; I.M Klotz and R.M Rosenberg; Wiley-Interscience, California, 2010.
- Statistical Thermodynamics; Revised Second Edition; M.C Gupta; New Age International Pvt Ltd., New Delhi, 2013.
- Physical Chemistry, A Molecular Approach; Viva Student Edition; D.A. McQuarrie and J.D Simon; Viva Books Private Limited, New Delhi, 2019.
- Thermodynamics for Chemists; Third Edition; S. Glasstone; Affiliated East -West Press Pvt. Ltd., New Delhi, 2015.
- Micelles: Theoretical and Applied Aspects, Y. Moroi, Springer International Edition, 2013.
- Advanced Physical Chemistry; Eighteenth Edition; J. N. Gurtu and A. Gurtu; Pragati Prakashan, Meerut, 2015.

PAPER CODE- CHY 224
Spectroscopy II
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to apprise the learners with the instrumentation involved in the various spectroscopic techniques, to enable them to understand and apply the key concepts of spectroscopy in the elucidation, characterization and inference of the relevant structural information of various known organic molecules and to make them extend the same to unknown organic compounds.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 224	Spectroscopy II	**The students will be able to-** CO63-differentiate between instrumentation tools and techniques of Mass/IR/UV Spectrometry. CO64-differentiate between the principles of various spectroscopic methods and work on problems of different regions of EMR Spectrum. CO65- identify the suitable technique for a class of molecules based on selection rules and fundamental theory of spectroscopy. CO66- employ the theoretical knowledge of techniques like COSY, NOSEY, HETCOR and DEPT to differentiate between compounds of different electronic, structural and functional constitution in 13C-NMR. CO67- interpret and distinguish between the structures of simple compounds using the Mass, IR and NMR spectra. CO68-predict the λmax for different organic compounds using Woodward-Feiser rules. CO69-correlate the theoretical and experimental results of spectroscopic analysis of organic molecules. CO70-associate advanced applications like MRI with the NMR principles and theory.	Class lectures Tutorials Group discussions Question preparation- Subjective type, Long answer, Short answer Objective type- Multiple choice questions, One answer/two answer type questions Assertion and reasoning	Quiz Written test Assignment Semester end examination

CONTENTS

I Mass Spectrometry 12 hrs

Introduction, generation- EI, CI, HEMS FD and FAB. Mass analyzer-electromagnetic field, quadrupole. Detection of molecular formula (HRMS) and determination of molecular formula, molecular ion, molecular ion peak, Nitrogen rule, isotope peak, metastable ions; Fragmentation: Basic fragmentation types and rules, factors influencing fragmentation, McLafferty rearrangement, fragmentation pattern of hydrocarbons, alcohols, ethers, ketones, aldehydes, carboxylic acids, amines, nitriles, nitro and halogenated compounds.

Self-Study: Problems of mass spectral fragmentation of organic compounds for structure determination.

II UV-Visible & Fluorescence Spectroscopy 12 hrs

Electronic transitions (185-800 nm), Beer-Lambert rule, hypsochromic & bathochromic shifts, effect of conjugation, solvent effects, chromophores & auxochromes. Characterization of organic compounds: Application of Woodward-Feiser rules to conjugated dienes, α,β-unsaturated carbonyl compounds, benzene and benzene derivatives, polycyclic aromatic hydrocarbons, polyenes and polyenynes, steric effects in biphenyls and applications.

Fluorescence spectroscopy: An introduction to fluorescence spectroscopy.

III IR Spectroscopy 10 hrs

Sampling, instrumentation and selection rules.

Quantitative studies: Force constants, relation between force constant and vibrational frequencies, an introduction to near IR Overtones, combination bands and fermi-resonance, factors effecting the shift in group frequencies: Isotope effect, hydrogen bonding, solvent effect, electronic effects (inductive and mesomeric) and steric effect, different absorption regions in IR spectrum and vibrational coupling.

Characteristics functional group absorptions in organic compounds: Carbon skeletal vibrations (alkanes, alkenes, alkynes, aromatic compounds), alcohols, phenols, ethers, ketones, aldehydes, carboxylic acids, amides, acid anhydrides, conjugated carbonyl compounds, esters, lactones, amines, amino acids (primary and secondary), interpretation of IR spectra of typical organic compounds.

IV Proton Magnetic Resonance Spectroscopy 12 hrs

Nuclear properties, Pulse technique, Fourier Transform technique and its advantages, quantum number, chemical shift and factors affecting chemical shift, spin-spin interaction, factors affecting coupling constant, shielding mechanism, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides and mercaptans), proton exchange, deuterium exchange, complex spin-spin interaction between two, three, four, and five nuclei (first order spectra).

Hindered rotation, Karplus curve: Variation of coupling constant with dihedral angle, simplification of complex spectra: nuclear magnetic double resonance, contact shift reagents, variable temperature dynamic NMR spectroscopy.

Solvent effects, Nuclear Overhauser Effect (NOE), a brief introduction of compounds carrying NMR active nuclei like ^{15}N, ^{19}F, ^{31}P.

V ^{13}C and Advanced NMR Techniques and Combined Applications of Spectroscopic Techniques. 14 hrs

^{13}C NMR spectroscopy*:* Basic principles, chemical shift, (aliphatic, olefinic, alkyne, aromatic, heteroaromatic & carbonyl carbon), proton (^{1}H) coupled ^{13}C NMR spectrum, off-resonance and noise decoupled ^{13}C NMR spectrum, DEPT. 2D-NMR spectroscopy– COSY, NOESY, HETCOR.

Structure elucidation of organic compounds by combined application of UV, IR, NMR and mass spectroscopy.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Spectrometric Identification of Organic Compounds; Sixth Edition; R.M. Silverstein and F.X. Webster; John Wiley and Sons, 2006.
- Organic Spectroscopy; Third Edition; W. Kemp; Palgrave Publisher Ltd., New York, 2004.
- Spectroscopic Methods in Organic Chemistry; Seventh Edition; D. H. Williams and I. Fleming; Springer International publishing, 2019.
- Spectral Analysis of Organic Compounds; Second Edition; C.J. Creswell and M.M. Campbell; Burgess Publishing Company, Great Britain, 1972.

PAPER CODE- CHY 225
Computer in Chemistry
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :
The course aims to help the students learn the basics of computers, working on various productivity softwares in order to deal with text formatting, statistical analysis, presentations and writing programs for solving various chemical equations.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 225	Computer in Chemistry	**The students will be able to-** CO71- learn the fundamentals of the computer system and its components. CO72-work on word processors and create well formatted documents. CO73-work on spreadsheets and employ basic functions, create charts, perform statistical analysis. CO74-work on presentation software and create effective presentations. CO75-learn C language and write programs for solving chemical equations.	Interactive lectures Group discussions Tutorials Quiz Problem solving sessions	Written test Viva-voce Group/Individual demonstrations Semester end examination

CONTENTS

I Introduction to Computers and Computing 4 hrs
History of computers, basic structure of computers, generation of computers, computer languages and their types, types of memory – Primary and secondary, input and output devices, differences between various types of operating systems, internet surfing through search engines.

II Introduction to Software Packages 6 hrs

Word Processor Software: Formatting, inserting tables, track changes, comments.
Spreadsheet Software: Autofill option, charts, basic functions, statistical analysis through Excel-setting the dependent & independent variables, measures of central tendency & dispersion, correlation coefficient, regression analysis of straight line relationship (least square method), regression coefficient, and criteria for rejection of an observation: T- test.
Presentation software: Creating a master slide, inserting images and tables, running a slide show, object linking and embedding (OLE).
Google Drive: Working on Google Docs, Google Sheets, and Google slides.
Simulation Software: Introduction.

III Programming in C 8 hrs

Principles of programming, algorithms and flowcharts, history of C language, constants and variables, data types, operations and symbols, expressions, arithmetic assignment statement, input and output format statement. Selection statements – if then else, nested if, switch case. Iterations and looping - for, while, do-while.

IV Applications in Chemistry- I 6 hrs

Development of small computer codes involving simple formulae in chemistry, such as Vander Waals equation, Henderson Hasselbach equation, integrated rate equation for first and second order reaction, radioactive decay, evaluation of lattice energy and ionic radii from experimental data.

V Applications in Chemistry- II 6 hrs

Development of small computer codes to calculate the molecular weights of organic compounds, determination of percentages of element in an organic compound, determination of molecular weights of organic compounds by experimental methods, to calculate wavelength for conjugated dienes and enones, to calculate bond order, electron density.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Computer Fundamentals; Fourth Edition; P. K. Sinha and P. Sinha, BPB Publications, 2007.
- Introduction to Computers; Seventh Edition; P. Norton; Tata McGraw Hill Education Private Ltd.; 2013.
- Programming in ANSI C; Sixth Edition; E. Balagurusamy; Tata McGraw Hill Education (India) Private Ltd.; 2014.

PAPER CODE- CHY 226
Inorganic Chemistry Lab II
(Practical)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives :

The course aims to make the students aware of the different chromatographic techniques, to make students learn about the synthesis of different metal complexes and to identify them with the help of IR spectra and to make students understand about the different concepts behind the gravimetric and volumetric techniques and its uses in separation of different metal ions from a given mixture.

Course Outcomes (Cos):

COURSE		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
CHY 226	Inorganic Chemistry Lab II	**The students will be able to-** CO76- apply the knowledge of volumetric and gravimetric techniques in separation and estimation of the amount of different metal ions present in the mixture. CO77- utilize the chromatographic techniques like paper chromatography and Thin Layer Chromatography for the separation and identification of metal ions. CO78- prepare inorganic complexes and interpret their IR spectra.	Interactive lectures Discussions Tutorials Problem solving	Written test Tutorials Semester end examination (Practical as well as written test) followed by Viva-voce

CONTENTS

Gravimetric/Volumetric Analysis

Quantitative Analysis

i. Separation and determination of two metals Ni-Zn, Cu-Fe and Cu-Ba involving volumetric and gravimetric methods.
ii. Separation and determination of three component mixture (one volumetrically and two gravimetrically, any two)
   a. Pb^{+2}, Zn^{+2}, Cu^{+2}
   b. Zn^{+2}, Cu^{+2},Fe^{+2}
   c. Cu^{+2} Fe^{+2}, Ni^{+2}
   d. Cu^{+2}, Ni^{+2}, Mg^{+2}

Chromatographic Separation

Paper chromatography

Separation, identification and determination of R_f value of the following (Any two)

i. Cu and Cd
ii. Ni and Mn
iii. Ni and Co

Thin layer chromatography

Separation and determination of R_f value of mixture of complexes containing metal ions-nickel, manganese, cobalt and zinc.

Synthesis

Preparation of selected inorganic complexes and their IR spectralstudies(any four)

i. Metal complexes of dimethyl sulphoxide, $CuCl_2$.2DMSO
ii. Metal oxalate hydrate complexes, Nickel dioxalate
iii. Phosphine, Ph_3P and its transition metal complexes

iv. Bisacetylacetonatocobalt (II)
v. Trisacetylacetonatoiron (III)
vi. Cis and trans bisglycinato copper (II) monohydrate
vii. $[VO(acac)_2]$

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
- Infrared and Raman Spectra: Inorganic and Co-ordination Compounds, Sixth Edition Part A & B; K.Nakamoto; John Wiley & Sons, Inc., New Jersey, 2009.

PAPER CODE- CHY 227
Physical Chemistry Lab II
(Practical)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives :
To develop experimental skills of various instruments (spectrophotometer, pH meter, polarimeter etc.). Knowledge of basic terms regarding phase equilibrium, thermochemistry, optical measurement and Lambert-Beer law

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 227	Physical Chemistry Lab II	**The students will be able to-** CO79- apply the knowledge of lab safety measures during the experimental work. CO80- prepare solution of desired concentration. CO81- explain the principles behind the experiments performed in the lab and calculate these values (stability constant, pKa value, partial molar volume), thermochemistry, phase equilibria CO82- perform experiments based on pH-metry, potentiometry and spectrophotometry. CO83- perform scientific experiments as well as accurately record experimental data with proper significant figure and analyze the results of such experiments.	Demonstration Discussion Group Activity	Practical performance Written test Google quiz Viva-voce Semester end examination (Practical as well as written test followed by Viva-voce)

CONTENTS

A list of experiments under different headings is given below. Students are required to perform 10-12 experiments (minimum two from each category).

Thermochemistry

i. To determine the solubility of benzoic acid at two temperatures in water-DMSO mixture (4:1) and to calculate the enthalpy change of the dissolution process.
ii. To determine the lattice energy of calcium chloride from its heat of solution using Born-Haber cycle. Provided the enthalpy changes for Ca^{+2} (g) → Ca(g), $2Cl^{-}$ (g) → 2Cl (g), Ca (g) → Ca (s), 2Cl (g) → Cl_2 (g) and Ca (s) + 2Cl (g) → $CaCl_2$ (s) are -451.1, 174.3, -38.8, -58.0 and -190.0 Kcal/mole respectively.
iii. To determine the partial molal volume of solute (KCl or NaCl) and solvent in a binary mixture at normal temperature and pressure.

iv. To determine the partial molar volume of methanol/ethanol-water system at normal temperature and pressure.

Phase Equilibrium

i To determine the solubility diagram for a three component liquid system chloroform, acetic acid and water / toluene, acetic acid and water / benzene ethanol and water. To discuss the diagram in a light of phase, component and degree of freedom.

ii Nernst Distribution Law: To determine the formula of a complex ion formed between cupric ion and ammonia by distribution method.

iii To study the freezing point curve of two component simple eutectic system (acetamide-benzoic acid/naphthalene-benzoic acid)

Polarimeter

i. To determine the rate constant of the inversion of cane sugar in presence of hydrochloric acid and sulphuric acid by using polarimeter and evaluate the relative strength of the two acids.

pH Metry

i. To titrate the given mixture of CO_3^{-2} and HCO_3^{-} ions against a strong acid, 0.1N HCl solution and to determine their strength.
ii. To determine pKa values of tribasic acid (H_3PO_4) against a strong base (NaOH).
iii. To determine the acidic and basic dissociation constant of an amino acid and hence its isoelectric point.
iv. To determine of pKa values of maleic/malonic acid by potentiometric titration with NaOH using glass electrode.

Spectrophotometry

i. To determine the acid dissociation constant (pKa value) of methyl red.
ii. To determine the stability constant and composition of $FeSCN^{+2}$ complex/ Fe(III)-salicylic acid/iron-phenanthroline complex/ zirconium alizarin red-S complex by jobs method of continuous variation and mole ratio method.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Experiments in Physical Chemistry; Fifth Edition, D. P. Shoemaker, C. W. Garland and J. W. Nibler, Mc Graw-Hill, New York, 1998.
- Introductory Practical Physical Chemistry; D. T. Burns and E. M. Rattenbury, Pergamon Press, 1966.
- Advanced Practical Physical Chemistry; Thirtieth Edition; J. B. Yadav; Krishna Prakashan Media Pvt. Ltd., Meerut, 2011.
- Experimental Physical Chemistry; First Edition; V. D. Athawale, P. Mathur; New Age International (P) Ltd. Publishers, New Delhi, 2011.

PAPER CODE- CHY 228
Research Methodology and Seminar
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :
The course aims to enable the learners to understand the basic concept of scientific writing, importance of literature survey and IPR for their seminar and dissertation works.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 228	Research Methodology and Seminar	**The students will be able to-** CO84- write an abstract /a small research paper/review paper by applying the basic concepts of scientific writing and literature survey. CO85-learn about the intellectual property right. CO86-utilize the basic concept behind the research methodology in writing the seminar and dissertation reports. CO87-improve their communication skills	Self-directed learning Group discussions Quiz	Power point presentation Report writing Semester end examination

CONTENTS

Part I: Research Methodology (20 hrs)

I Epistemology: Sources of knowledge. Rationalism and empiricism. Assumptions and Limitations of science, philosophy, logic and ethics, Science and technology. Theory, law, postulate. **4 hrs**

II Hypothesis: Types, characteristics. Chemistry and chemical knowledge. Scientific method: research process, causality, experimental research. Data analysis: Mean and standard deviation; absolute and relative errors, linear regression, covariance and correlation coefficient. **4hrs**

III Literature Survey: Importance, types of sources. Databases collection, collation, management and retrieval of references. Scientometry-citations, impact factor, H-index. **4 hrs**

IV Scientific Writing: Types of research papers, writing of research paper, review, thesis. Reviewing process of research paper. Ethics in research and publishing. **4 hrs**

V Intellectual Property Right (IPR): Tangible and intangible assets, IP and IPR, Types of IPR, Issues related to patenting, format of patent. **4 hrs**

Part II: Seminar (10 hrs)

The candidates will have to choose a topic either from the recent advancements in chemistry or syllabi for seminar preparation. They will be expected to submit a write up pertaining to that topic and at the end of semester, a presentation will have to be made in presence of panel of experts from different fields of chemistry.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Research Methodology and Scientific Writing; C. G. Thomas, Ane Books Pvt. Ltd, New Delhi 2016.
- Research Methodology: Methods and Techniques; Fourth Edition; C. R. Kothari and Gaurav Garg, New Age International Publisher,2019.
- www.wipo.int
- www.ipindia.nic.in
- Intellectual Property: Patents, Trademarks and Copyright in a Nutshell; A. R. Miller and M. H. Davis; West Group Publishers, 2000.
- The Law of Patents-With a Special Focus on Pharmaceuticals in India; *F. A. Khader;* Lexis Nexis Publication,*2007*.
- Intellectual Property Rights in the WTO and Developing Countries; J. Watal; Oxford University Press, Oxford.

COURSE OUTCOMES- Semester III
PAPER CODE- CHY 321
Synthesis & Retrosynthesis in Organic Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to provide an in-depth knowledge of various photochemical reactions & their basic principles which enables students to learn a variety of photochemical reactions and their mechanisms. They will also understand the various organic transformation through disconnection approach.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 321	Synthesis & Retrosynthesis in Organic Chemistry	**The students will be able to-** CO88- distinguish between thermal and photochemical energies and their effect on the course of chemical reactions. CO89- explain various pericyclic reactions i.e. Electrocyclic reactions, Cycloaddition reactions and Sigmatropic reactions. CO90- comprehend the orbital interactions and orbital symmetry correlations of various pericyclic reactions. CO91- use / predict retrosynthesis of organic molecules and develop an approach to devise synthetic methods.	Interactive lectures Discussions Tutorials Problem solving	Written test Quiz Assignment Tutorial Group activity Semester end examination

CONTENTS

I Basics of Photochemistry and Photochemical Reactions of Carbonyl Compounds 12 hrs

Laws of photochemistry. Fate of excited molecules - Jablonskii diagram, intersystem crossing, energy transfer, photosensitization, quenching, quantum yield, Stern-Volmer equation. Photochemical reactions of ketones – alpha cleavage or Norrish type I cleavage, gamma hydrogen transfer or Norrish type II cleavage; photo reductions; Paterno-Buchi reactions; Photochemistry of α,β-unsaturated ketones, β,γ-unsaturated ketones, cyclohexadienones (cross conjugated and conjugated).

II Photochemistry of Alkenes and Aromatic Compounds 10 hrs

Photochemistry of alkenes**:** Intramolecular reactions of the olefinic bond **–** cis**-**trans isomerisation (stilbene), cyclization reactions, rearrangement of 1,4 and 1,5-dienes, di-π methane rearrangement.
Photochemistry of aromatic compounds: Photochemical rearrangement, photostationary state, 1, 3, 5 – trimethyl benzene to 1, 2, 4-trimethyl benzene.

Miscellaneous Photochemical Reactions**:** Barton reaction, photo Fries rearrangement of ethers and anilides, singlet oxygen reactions **(**photo oxygenation).

III Pericyclic Reactions -I 10hrs

General characteristics, classification, molecular orbital symmetry.

Electrocyclic reactions: Theories of explanation (FMO, Woodword-Hoffmann and PMO approach), frontier orbitals, electrocyclisation and reterocyclisation of 1,3 butadiene, cyclobutadiene and ,hexatriene derivatives, allylic cations(1,5 diphenylpentadienyl cation) and allylic anions (1,5 diphenylpentadienyl anion), ring opening in bicycle [4.1.0] heptane derivatives, valence tautomerism.

IV Pericyclic Reactions–II 10hrs

Cycloaddtion reactions: 2+2, 4+2 cycloaddition, 1, 3-dipolar cycloaddition and cheletropic reactions; stereoselectivity (endo, exo), stereospecific and regioselective hydrogen reactions, Lewis-acid catalysis in Diels' Alder reaction.

Sigmatropic rearrangements*:* Suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3, 3- and 5, 5-sigmatropic rearrangements; Claisen, Cope and Aza-Cope rearrangements; Isomerization of divinyl cyclopropane; Fluxional tautomerism (bullvalene); Ene reaction.

V Disconnection Approach in Organic Synthesis 18hrs

Synthons and synthetic equivalents, Types-d^1, d^2, d^3 and d^4 synthons, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis; principle of protection of alcohol, amine, carbonyl and carboxyl groups.

One and Two Group C-C Disconnections:

Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, uses of alkynes and aliphatic nitro compounds in organic synthesis; Diels' Alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds, Michael addition and Robinson annelation.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- CRC Handbook of Organic Photochemistry and Photobiology; Second Edition; W. Horspool and F. Lenci; CRC Press LLC, US, 2004.
- Fundamentals of Photochemistry; Third Edition; K.K. Rohatagi and Mukherjee; New Age International Publishers Pvt. Ltd., New Delhi, 2007.
- Molecular Reactions and Photochemistry; First Edition; C. H. Depuy and L. Orville Chapman; Prentice-Hall of India Pvt. Ltd, New Delhi, 1988.
- Reaction Mechanism in Organic Chemistry; Third Edition; S.M. Mukherjee and S.P. Singh; Macmillan, India Ltd., New Delhi, 2003.
- Advanced Organic Chemistry Part A & B; Fifth Edition; F. A. Carey and R. J. Sundberg; Springer, US, 2007.
- Designing Organic Synthesis: A Programmed Introduction to the Sython Approach; First Edition; S. Warren; John Wiley and Sons, Great Britain, 2010.
- Organic Synthesis- Concepts, Methods and Starting Materials; J. Fuhrhop and G.Penzillin; Second Edition; Wiley-VCH, New York: 2003.
- Modern Methods of Organic Synthesis; Fourth Edition; W. Carruthers; Cambridge Univ. Press, UK, 2005.

PAPER CODE- CHY 322
Organometallic Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to develop a vast knowledge about different reactions leading to the formation of various organometallic complexes and the mechanism involved in homo- and heterogeneous catalysis, to make the students learn about the various applications of organometallic complexes in catalysis and to acquaint them with the promising future of organo-transition metal chemistry in industrial, biological and environmental fields.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 322	Organometallic Chemistry	**The students will be able to-** CO92- explain valence electron counts in organometallic compounds CO93- discuss the symmetry, structure and bonding of M-C σ bonded and M-C multiple bonded organometallic compounds CO94- explain about the mode of action of a catalyst. CO95- differentiate between terminal and bridging carbonyls and will be able to interpret the type of bonding on the basis of IR spectra.	Interactive lectures Discussion Tutorials Multimedia presentations	Written test Google quiz Assignment Semester end examination

CONTENTS

I **Introduction to Organometallic Compounds** **10hrs**
Types of transition metal to carbon bonds. Classification of organometallic compounds based on hapticity and polarity of M-C bond. Nomenclature and general characteristics, electron counting (16 and 18 electron rules).
Routes of synthesis for σ-alkyls and aryls of transition metals, stability of organometallic compounds and decomposition pathways; Organocopper in organic synthesis.

II **Metal-Carbon Multiple Bonded Organometallics-I** **10 hrs**
Preparation, properties, structure and bonding of -carbene and carbine complexes (both Fischer and Schrock types), nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

III **Metal-Carbon Multiple Bonded Organometallics-II** **13hrs**
Preparation properties, structure and bonding of η^4- diene complexes, η^5- dienyl complexes, η^6- arene & triene complexes (nucleophilic and electrophilic substitution), fluxionality and dynamic equilibria in such as η^2- olefin, η^3- allyl and η^5-dienyl complexes.

IV **Catalysis by Organotransition Metal Complexes** **15 hrs**

Principles and important reactions of transition metal organometallics: Co-coordinative unsaturation oxidative addition, insertion and product isolation(reductive elimination and β-elimination).

Homogeneous catalysis: Hydrogenation of alkenes, hydrosilylation of alkenes, metathesis of alkenes, oligomerization and polymerization of alkenes and alkynes, hydroformylation of alkenes, acetic acid synthesis and other carbonylation reactions, oxidation reactions of alkenes.

Heterogeneous catalysis: Fischer Tropsch process- Methanation reaction, synthesis of methanol, gasoline production, water gas shift reaction, role of ZnO/Cr_2O_3 in the reaction, acetic acid synthesis, role of CO catalyst.

V Metal π-Complexes 12hrs

Metal carbonyls: Preparation, properties, structure and bonding with special reference to dinuclear and polynuclear carbonyls; Vibrational spectra of metal carbonyls (bridging and terminal) for bonding and structural elucidation, dinitrogen and dioxygen complexes; Metal carbonyl clusters.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- The Organometallic Chemistry of the Transition Metals; Fourth Edition; R. H. Crabtree; John Wiley and Sons, Inc., New Jersey, 2005.
- Organometallic Chemistry: A Unified Approach; Second Edition; R.C. Mehrotra and A.Singh; New Age International Private Limited, New Delhi, 2000.
- Inorganic Chemistry; Fifth Edition; Gary L. Miessler and Donald A. Tarr; Pearson Education Inc. Singapore, 2013.
- Inorganic Chemistry (Principle and Structure and Reactivity); Fourth Edition; J. E Huheey, E. A. Keiter, R. L. Keiter; Pearson India, New Delhi, 2013
- Advanced Inorganic Chemistry, Sixth Edition; F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann; John Wiley and Sons, USA, New York, 2007.
- Concepts and Models of Inorganic Chemistry; Third Edition; B. Douglas, D. McDaniel; John Wiley and Sons, India, 2006.

PAPER CODE- CHY 323
Electrochemistry and Chemical Kinetics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to make the student aware about the behaviour of ions in solution and structure of electrode surface. Students are able to learn about the rate laws from a proposed mechanism and to analyze kinetics in gases and solutions.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 323	Electrochemistry and Chemical Kinetics	**The students will be able to-** CO96-explain different theories to understand the behavior of strong electrolytes. CO97-interpret the structure and nature of electrical double layer and describe electro kinetic phenomena. CO98-explain kinetics of electrode reactions with the help of Butler-Volmer equation and Tafel equation. CO99-describe dynamics of unimolecular reactions and discuss salt effect. CO100-determine rate law for a complex reaction using steady state approximation.	Class lectures Demonstrations Group discussions	Written test Presentation Google quiz Assignment Semester end examination

CONTENTS

I Ions in Solution 8 hrs

Debye Huckel theory of strong electrolytes, Debye Huckel Onsager equation, activity coefficient, mean ionic activity coefficient, physical significance of activity coefficients, mean activity coefficient of an electrolyte and its determination,ionic strength, Debye Huckel theory of mean ionic activity coefficient, Debye-Huckel limiting law, qualitative and quantitative verification of Debye-Huckel limiting law, Debye length, ionic strength, Bjerrum model of ion-association.

II Electrochemistry: Electrical Double Layer 12hrs

Introduction, evidences and structure of electrical double layer- Helmholtz-Perrin, Guoy-Chapman, Stern theory, measurement of zeta potential (electrokinetic phenomena), influence of ions on electrokinetic phenomena, electro capillary phenomenon: Electro capillary curves, Lipmann's equation.
Graham, Devanathan, Mottwatts-Tobin, Bockris-Devanathan-Müller models. Quantum aspects of charge transfer at electrodes-solution interfaces, tunneling.

III Kinetics of Electrode Reactions 14hrs

Electrodics of elementary electrode reactions: Determination of anode and cathode potential, decomposition voltage of electrolyte, diffusion over potential, hydrogen and oxygen over voltage, influence of various factors on over voltage, theoretical investigation of kinetics of an electrode reaction: Standard rate constant (k^0) and transfer coefficient (α), exchange current. Butler-Volmer equation, Tafel equation. Electrocatalysis: Introduction and influence of various parameters.

Semiconductor solution interfaces, effect of light at semiconductor solution interface.

IV Statistical Theories of Kinetics 13 hrs

Collision theory of reaction rates, steric factor, activated complex theory, comparison between collision theory and activated-complex theory. Unimolecular gas reactions: Dynamics of unimolecular reactions (Lindemann, Hinshelwood, RRK and RRKM theories), primary and secondary salt effects: Influence of ionic strength and dielectric constant on reactions involving (i) ions (ii) dipoles (iii) ion and dipole.

V Complex Reactions 13 hrs

Equilibrium and steady state approximation and their application in reaction mechanisms, rate expression for opposing, parallel and consecutive reactions, kinetic and thermodynamic control of the reactions, chain reactions: Thermal and photochemical reactions, dynamic chain (mechanism of hydrogen-bromine and hydrogen-chlorine reactions), decomposition of ethane, pyrolysis of acetaldehyde, oscillatory reactions: Belousov-Zhabotinsky reaction.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Modern Electrochemistry Vol. I, II A & II B; Second Edition; J.O'm. Bockris and K.N. Reddy; Kluwer Academic Publishers, New York, 2001.
- An Introduction to Electrochemistry; Seventh Edition; S. Glasstone, Affiliated East-West Press Pvt. Ltd., New Delhi, 2016.
- Electrochemistry- Principles, Methods and Applications; First edition, C. M. A. Brett and A. M. O. Brett; Oxford University Press, Great Britain, 1994.
- Chemical Kinetics; Third Edition; K.J. Laidler; Pearson Education Pvt. Ltd., Singapore, 2013.
- Kinetics and Mechanisms of Chemical Transformations; First Edition; J. Rajaram and J.C. Kuriacose; Macmillan Publisher India Ltd., New Delhi, 2009.
- Advanced Physical Chemistry; Eighteenth Edition; J. N. Gurtu and A. Gurtu, Pragati Prakashan, Meerut 2015.

PAPER CODE- CHY 324
Nuclear and Analytical Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to provide knowledge about the working principle of counters and applications of radioactive isotopes, to acquaint the students with the separation process using various chromatographic techniques and to make them understand about quantitative measurements in the absorption and emission spectroscopy and use of electrochemistry in practical applications.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 324	Nuclear and Analytical Chemistry	**The students will be able to-** CO101-learn the basics and advanced applications of nuclear chemistry. CO102-learn the applications of various thermal techniques. CO103-use different chromatographic techniques in the separation & identification of components of a system. CO104-learn electro analytical, imaging and optical techniques.	Class lectures Tutorials Group discussions Question preparation- Subjective type- Long answer, Short answer Objective type- Multiple choice questions, One answer/two answer type questions Assertion and reasoning	Written test Google quiz Assignment Semester end examination

CONTENTS

I Nuclear Chemistry 12 hrs

Types of radioactive decay, Decay kinetics: decay constant, units of radioactivity, Parent-daughter growth relationship.
Counters – Geiger counter, scintillation counter, proportional counter, semiconductor detector. Nuclear reaction – evaporation, spallation, fragmentation, transfer reactions (Buckshot hypothesis), nuclear fission: Theory of nuclear fission , fission fragments , their mass and charge distribution, fission energy, compound nucleus theory for nuclear reaction, Photonuclear reaction and nuclear fusion(thermonuclear reaction), nuclear reactors Interaction of radiation with matter .
Self-Study: Sub-nucleons, classification of nuclides, nuclear stability, binding energy, nuclear radius, nuclear models – liquid drop model, shell model.

II Nuclear and Thermal Methods 12 hrs

Nuclear Methods: Applications of radio isotopes as tracers: Chemical investigations (structure determinations, reaction mechanism, isotope exchange reactions), age determination, medical, agricultural and industrial applications.
Analytical applications (neutron activation analysis and isotope dilution analysis)
Thermal Methods: Theory and applications of TGA, DTA, DSC and thermometric titrations

III Separation Methods 14 hrs

Prerequisite: Theory and applications of Paper & Thin Layer Chromatography.
Theory and applications of solvent extraction, ion exchangers including liquid ion exchangers and chromatographic methods for identification and estimation of multicomponent systems (such as GC, HPLC, CC)
Hyphenated Techniques: Instrumentation and applications of GC-IR, TG-IR Spectroscopy, GC-Mass Spectroscopy.

IV Electroanalytical Methods and Imaging Techniques 11 hrs

Instrumentation and applications of polarography (DC, AC and Pulse), cyclic voltammetry, coulometry and anode stripping voltammetry. Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM): Instrumentation and applications.

V Optical Methods 11 hrs

Instrumentation and applications of UV-Visible, X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Electron Spectroscopy for Chemical Analysis (ESCA), Atomic Absorption Spectroscopy (AAS), Atomic Emission Spectroscopy (AES).

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Essentials of Nuclear Chemistry; Fourth Edition; H.J. Arnikar; New Age International (P) Ltd., New Delhi, 2016.
- Nuclear Chemistry for B.Sc. and M.Sc. Students of Indian Universities; First Edition; C.V. Shekhar; Dominant Publishers and Distributors, New Delhi, 2003.
- Fundamentals of Analytical Chemistry, Eighth Edition; D.A. Skoog, D.M. West and F.J. Holler; Saunders College Publishing, Philadephia, 2007.
- Principles of Instrumental Analysis; Seventh Edition; Skoog, D.A., Holler F.J. and S.R. Crouch; Cengage Learning, USA, 2016
- Instrumental Methods of Analysis; Seventh Edition; Willard, Hobert H. et. al, CBS, 2004
- Basic Concepts of Analytical Chemistry; Fourth Edition; Khopkar, S.M., New Age International Pvt Ltd, 2020.
- Element of X-Ray Diffraction; Third Edition; B.D. Cullity & S.R. Stock, Pearson Education, Delhi, 2014.
- Fundamental Concepts of Inorganic Chemistry; First Edition; Vol. 7; A.K. Das, & M. Das, CBS Publishers, New Delhi, 2014.

PAPER CODE- CHY 325
Environmental Chemistry
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :
The course aims to equip students with the knowledge of the chemical and photochemical reactions essential for the emergence and existence of the cycling and accumulation of pollutants in the environment, to address the chemistry of elements and compounds in the atmosphere and water, to lay special emphasis on the processes that define the connections and the dependence between individual segments of environment and to develop perspective on sustainability.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 325	Environmental Chemistry	**The students will be able to-** CO105- discuss the concept of structure and function of different compartments of the environment. CO106- analyse the national and global environmental issues relating to atmosphere, water and natural resources CO107- criticize the range and extent of the water pollution problem with an understanding of some of the treatment procedures available CO108- develop scientific perspective of the issues confronting our present-day environment CO109- identify relationships between chemical exposure and effects on physiological system CO110- demonstrate different ways of conservation of the natural resources and their management	Interactive lectures Discussions Tutorials Problem solving	Written test Google quiz Assignment Semester end examination

CONTENTS

I General Aspects of Environmental Chemistry 7 hrs

Atmosphere and its interaction with hydrosphere, lithosphere and biosphere. Composition of air, water, soil.

Atmospheric layers, vertical temperature profile, heat radiation budget of the earth atmosphere system. Properties of troposphere, thermodynamic derivation of lapse rate. Temperature inversion, pressure variation in atmosphere and scale height.

Biogeochemical cycles of nitrogen and sulphur.

Earth's carbon cycle, carbon emitters, carbon sequestration, carbon footprint and carbon trading.

II Chemical and Photochemical Reactions in Atmosphere 7 hrs

Formation and reactions of O_3, O_2, NO_x, SO_2, hydroxyl radical, hydroperoxyl radical, organic radicals, etc.

Photochemical smog, green-house effect, ozone depletion and acid rain. Effects and control of air pollutants-gaseous, particulates.

III Chemistry of Hydrosphere 6hrs

Chemical reactions in aquatic environment, concept of oxygen demand -DO, BOD, COD, TDS, pH, conductivity, colloids, salinity. Aquatic pollution: Sources (Inorganic and organic pollutants, pesticides, industrial effluents, sewage, detergents and oil spills), effect of pollutants on aquatic life (flora and fauna). Purification and treatment of water.

IV Environmental Toxicology 5 hrs

Toxicology: Threshold limiting value (TLV), LD_{50}, toxicity and control of toxicants: nonmetallic compounds, asbestos, organic compounds (POP's, phthalate, dioxins, PCB's), pesticides, VOCs, endocrine disrupters.

V Renewable Energy 5hrs

Introduction, applications, merits and demerits: Solar energy, biomass energy, hydrogen fuel cells, hydrothermal energy, wind energy and geothermal energy.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Environmental Chemistry, Tenth Edition; Stanley E. Manahan; CRC Press; 2017
- Environmental Chemistry, Fifth Edition; Colin Baird; W.H. Freeman and company, New York, 2012.
- Environmental Chemistry, Ninth Edition; A. K. De; New Age International Pvt. Ltd., New Delhi, 2018
- Chemistry of the Environment, Revised Third Edition; Thomas G. Spiro & William M. Stigliani; University Science Book, New Delhi, 2011.

PAPER CODE- CHY 326
Research Projects
(Project)

Credits:2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives :
The course aims to demystify the basics of literature survey. It will outline the fundamentals of doing research project, aimed primarily, but not exclusively, at the postgraduate level. It places the student experience at the center by engaging learners in a range of robust and challenging discussions and exercises such as field visits.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 326	Research Projects	**The students will be able to-** CO111-write a report on the field/industrial visit. CO112- write a literature review on the topic of interest. CO113-improve their communication skills.	Field visits Documentation	Report writing Quiz Viva

This has been incorporated, with the aim that a candidate does extensive literature survey on a topic of choice and further take up project or dissertation on the same topic in the subsequent semester.

Total Marks allotted 100

Internal		**External**			
30 %		70 %			
Work visit report& presentation	Dissertation synopsis	Synopsis presentation& viva	Survey of Literature	Write-up	References
15 marks	**15 marks**	**20 marks**	**20 marks**	**15 marks**	**15 marks**

To give the exposure of industries, field visits will be organized. Students will either prepare a report of the visit or a quiz may be organized which will be evaluated in presence of panel of experts.

PAPER CODE- CHY 327
Organic Chemistry Lab II
(Practical)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives :
The course aims to provide knowledge of synthesis by conventional and non-conventional methods, handling of hazardous chemicals, and to enhance learning of physical and spectroscopic techniques.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 327	Organic Chemistry Lab II	**The students will be able to-** CO114- characterize organic molecules by physical and spectroscopic methods including mp, bp, IR, NMR and chromatography CO115- demonstrate and apply common laboratory techniques, including refluxing, distillation, steam distillation, recrystallization, vacuum filtration, extraction, thin layer chromatography, column chromatography in the specific synthesis etc. CO116- use spectrophotometric techniques for the estimations of some biomolecules.	Interactive Lectures Discussions Tutorials	Written test Google quiz Viva-voce Semester End Exam (Practical as well as written test followed by Viva-voce).

CONTENTS

Synthesis (Green Methods / Conventional Methods)

a. One step synthesis
- Aldol condensation (Synthesis of dibenzal propanone)
- Acetylation (synthesis of acetanilide from aniline)
- Pechmann Condensation for Coumarin synthesis (Clay catalyzed solid state synthesis of 7-hydroxy -4-methyl coumarin)
- Bromination of phenol

b. Two step synthesis (any three)
- Benzoin → benzil → benzilic acid
- Benzophenone → benzpinacol → benzpinacolone
- Acetanilide → p-bromoacetanilide → p-bromoaniline
- Acetanilide → p-nitroacetanilide → p-nitroaniline
- Resorcinol → flouroscein → eosin

- Phthalicanhydride → phthalimide → anthranilicacid

Extraction of Organic Compounds from Natural Resources (any three)

- Isolation of caffeine from tea leaves.
- Isolation of casein from milk.
- Isolation of lactose from milk.
- Isolation of nicotine dipicrate from tobacco.

Spectroscopy

Identification of organic compounds (with emphasis on isomeric studies andcalculation of % ratio of tautomers) by the spectral analysis.

Spectrophotometric Estimations (any three)

- Protein
- Carbohydrate
- Cholesterol
- Phosphate
- Ascorbic acid

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Vogel's Textbook of Practical Organic Chemistry; Fifth Edition, B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell; Addison – Wesley Publishing Company, 2014.
- Practical Organic Chemistry; Fourth Edition; F.C. Mann and B.C. Saunders; Pearson Education, New Delhi, 2013.
- Advanced Practical Organic Chemistry; J. Leonard, B. Lygo and G. Procter; Third Edition; CRC Press, 2013.

PAPER CODE- CHY 328
Physical Chemistry Lab II
(Practical)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives :
The course aims to develop advanced hands on experience in the operation of conductivity meter, dropping mercury electrode and potentiometer. Acquire the knowledge of basic terminology regarding conductance, chemical kinetics, adsorption, polarography and potentiometry.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 328	Physical Chemistry Lab II	**The students will be able to-** CO117-acquire knowledge of safe laboratory practice by handling laboratory glasswares, equipments, instruments and chemical reagents. CO118-prepare standard solutions. CO119-understand the principle behind the experiments performed in the lab. CO120-predict the kinetics of different reactions. CO121-verify the Onsagar equation experimentally and apply it for determination of equivalent conductance of weak and strong electrolytes. CO122-perform scientific experiments as well as accurately record experimental data and analyze the results of such experiments.	Interactive Lectures Discussions Demonstrations	Written test Viva Voce Semester End Exam

CONTENTS

A list of experiments under different headings is given below. Students are required to perform at least 8-10 experiments.

Chemical Kinetics

i. To determine the effect of (a) change of temperature (b) change of concentration of reactants and (c) catalysts on the velocity constant of hydrolysis of an ester.
ii. To study the kinetics of the reaction between $K_2S_2O_8$ (potassium persulphate) and KI (potassium iodide) and to determine the rate constant and the energy of activation of the reaction.

iii. To determine of primary salt effect in the kinetics of ionic reaction and to test the Bronsted relationship (Iodide ion is oxidized by persulphate ion).
iv. To study the kinetics of saponification of ethyl acetate by sodium hydroxide and to determine the rate constant.
v. To determine the rate constant, energy of activation and entropy of activation in the oxidation of benzyl alcohol ($C_6H_5CH_2OH$) by potassium permanganate in acidic medium.
vi. To determine the formation constant for the (Ce^{+4}-H_3PO_2) intermediate complex and its decomposition rate constant at the room temperature.
vii. To determine the rate constant for the bleaching of malachite green in basic medium at room temperature spectrophotometrically.
viii. To determine the rate constant, order of reaction and energy of activation for saponification of ethyl acetate using NaOH conductometrically.

Electrochemistry

i. To estimate the concentration of H_2SO_4, CH_3COOH and $CuSO_4$ by conductometric titration using NaOH solution.
ii. To determine equivalent conductance of the strong electrolytes (KCl, HNO_3, HCl etc.) at several concentrations and to verify the Onsagar's equation and find the values of a and b in the equation.
iii. To determine the equivalent conductance of acetic acid at infinite dilution and to calculate its degree of dissociation at different dilutions as well as dissociation constant at the room temperature.

Potentiometry

i. To determine the concentration of ferrous ion in the given solution by titrating against N/10 $Cr_2O_7^{--}$ or Ce^{+4} ion solution and also determine the equivalence point by plotting E *vs.* V, ΔE *vs.* ΔV and $\Delta^2E/\Delta V^2$ *vs.* ΔV.

Polarography

i To determine the half wave potentials of Cd^{+2} and Zn^{+2} ions in 0.1 M KCl solution and to show that half wave potential is independent of the concentration.

Adsorption

i. To study the adsorption of acetic acid or oxalic acid from aqueous solution by activated charcoal or animal charcoal and to examine the validity of Freundlich and Langmuir adsorption isotherms.
ii. To compare cleansing power of samples of two detergents.
iii. To study the variation of surface tension of solution of n-propyl alcohol with concentration and to determine the limiting cross section area of alcohol molecule.
iv. To determine the radius of molecule by viscosity measurements (e.g. Glycerol)

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Advanced Practical Physical Chemistry; Thirtieth Edition; J. B. Yadav; Krishna Prakashan Media Pvt. Ltd., Meerut, 2011.
- Experimental Physical Chemistry; First Edition; V. D. Athawale, P. Mathur; New Age International (P) Ltd. Publishers, New Delhi, 2011.
- Experimental Physical Chemistry; R. C. Das and B. Behera; Tata Mc-Graw Hill Publishing Co. Pvt. Ltd., 1993.
- Experiments in Physical Chemistry; Fifth Edition, D. P. Shoemaker, C. W. Garland and J. W. Nibler, Mc Graw-Hill, New York, 1998.
- Introductory Practical Physical Chemistry; D. T. Burns and E. M. Rattenbury, Pergamon Press, 1966.

COURSE OUTCOMES- Semester IV
PAPER CODE- CHY 421
Strategies in Organic Synthesis
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The aim of the course is to give advanced knowledge in synthetic organic chemistry so that the learner can suggest alternative reagents and reactions for performing desired organic transformations. It is also aimed at making students aware of the basic principles and applications of green chemistry so that they acquire the competence to think, design and develop sustainable chemistry.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 421	Strategies in Organic Synthesis	**The students will be able to-** CO123-plan an organic synthesis using suitable reagents to understand a range of more sophisticated approaches to synthesis (building on the knowledge from previous years) that exploit the properties of other elements (particularly phosphorous, sulphur, silicon, boron, lithium, lanthanides and certain transition metals) CO124-apply chemistry involving main group and transition metallic reagents to the synthesis of complex organic compounds. CO125-explain/justify the selection of one type of reagent and reaction conditions over another in terms of efficacy in relation to a particular synthetic problem. CO126-analyze the environmental impacts of chemistry and discover the importance of Green Chemistry. CO127-apply the green chemical sustainable tools for cleaner environment & energy.	Interactive Lectures Discussions Tutorials Quiz Problem solving	Written test Google Quiz Assignment Semester End Exam

CONTENTS

I Oxidation Reactions 14hrs

Metal-based and non-metal based oxidations of:

(a) Alkenes to alcohols/carbonyls-hydroboration-oxidation, chiral boranes, Wacker oxidation, SeO2/ selenium oxidants, chromium based oxidation.
(b) Alkenes to epoxides (peroxides/per acids based)-Sharpless asymmetric epoxidation, Jacob-Katsuki epoxidation, Shi epoxidation.
(c) Alkenes to diols (manganese, osmium based)- Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification.

(d) Ketones to ester/lactones- Baeyer- Villiger.
(e) Alcohols to carbonyls- Corey-Kim oxidation, Dess-Martin oxidation, Swern oxidation.Manganese, aluminium, hypervalent iodine and TEMPO based reagents.

II Reduction Reactions 12hrs

(a) Catalytic hydrogenation (Homogeneous hydrogenation: Wilkinson, Noyori asymmetric hydrogenation, stereo and enantioselective hydroboration.
(b) Metal based reductions : Li and Na in liquid ammonia, Birch reduction, Mc Murry, acyloin formation
(c) Hydride transfer reagents.
(d) $NaBH_4$, triacetoxyborohydride, L-selectride, K-selectride, Luche reduction; $LiAlH_4$, DIBAL-H, and Red-Al, trialkylsilanes and trialkylstannane, Meerwein-Pondorff-Verley reduction. Clemmenson and Wolff-Kishner reduction.

III Newer Synthetic Reactions 16hrs

(a) Metal mediated C- C and C-X coupling reactions: Suzuki, Heck. Stille, Sonogashira cross coupling, Buchwald-Hartwig amination and Negishi, Kumada coupling reactions. Umpolung.
(b) C=C Formation Reactions: Wittig reactions and its modifications, Shapiro, Bamford-Stevens. Julia-Lythgoe olefination and Peterson's stereoselective olefination, phosphorus, sulphur and nitrogen ylides, Stork-enamine reaction.
(c) Multicomponent Reactions: Mannich, Biginelli, Hantzsch, Passerini. Ugi reaction.
(d) Ring Formation Reactions: Pausan-Khand reaction, Bergman cyclisation,Nazarov cyclisation.
(e) Click Chemistry: Criteria for Click reaction, Sharpless azide cycloadditions.
(f) Olefin metathesis: Shrock's, Grubb's 1st and 2nd generation catalyst. Grubb-Hoveyda catalyst. Olefin cross metathesis (OCM), ring closing metathesis (RCM), ring opening metathesis (ROM) and applications.

IV Organocatalysis 8 hrs

Definition, generic modes, classification.
Covalent organocatalysis: Secondary amines via enamine, imine, imim ion, Amidines, guanidines , Lewis base catalysis, Nitrogen Heterocyclic Carbenes (NHC), synthesis, structure, catalysis-homo-and cross-benzoin condensation, Stetter reaction, hydrosilylation of styrenes, transesterification.
Noncovalent organocatalysis: Hydrogen bonding catalysis, thiourea based catalysts, Diols: TADDOL.
Phosphorus containing organocatalysts: Triphenylphosphine, Binol-derived phosphoric acids, cyclic diphosphazanes, phosphonates.

V Green Chemistry 10 hrs

Green Chemistry & sustainability, twelve principles of green chemistry, atom economy, E-factor.
Green chemistry tools:
Solvents: Types based on hazards, applications, green solvents-supercritical fluids, ionic liquids, water, solvent free solid phase reaction.
Alternative energy sources: Ultrasound, microwave, reactions at high pressure in constrained media.
Renewable sources, C1 chemistry.
Green catalysts: Types, advantages and disadvantages, applications in organic synthesis.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Organic Chemistry; First Edition; J. Clayden, N. Greeves, S. Warren and P. Wothers; Oxford University Press, 2009.

- Advanced Organic Chemistry: Reactions, Mechanisms and Structure; Seventh Edition; J. March; John Wiley and Sons Asia Private Limited, New Delhi, 2015.
- Advanced Organic Chemistry Part A & B; Fifth Edition; F. A. Carey and R. J. Sundberg; Springer, US, 2007.
- A Guidebook to Mechanism in Organic Chemistry; Sixth Edition; P. Sykes; Pearson Education, Delhi, 2011.
- Reaction Mechanism in Organic Chemistry; Third Edition;S. M. Mukherjee and S. Singh; Macmillan India Ltd., New Delhi, 2003.
- Mechanism and Theory in Organic Chemistry; Third Edition; T.H. Lowry; Addison– Wesley Publishing Company, 1999.
- Organic Chemistry; Fifth Edition; S.H. Pine; Tata McGraw Hill Publishing Company,2007.
- Modern Methods of Organic Synthesis; Fourth Edition; W. Carruthers; Cambridge Univ. Press, UK, 2005.
- Principles of Asymmetric Synthesis; Second Edition; R. Gawley and J. Aube; New York: Pergamon Press, 2012.

PAPER CODE- CHY 422
Research projects
(Project)

Credits: 10
Maximum marks: 100
Contact Hrs/Week: 10
Total Hrs: 150

Course Objectives :
The aim of the course is to give students an opportunity to investigate and to develop research skills to carry out research project.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 422	Research Projects	**The students will be able to-** CO128-demonstrate how to devise a research question or questions that frames your study. CO129-plan a piece of research work with regard to the task requirement and to the resources available.	Self-motivated learning Literature survey Report writing	Power point presentation Viva

To give an exposure of research to candidates, dissertation has been introduced in semester IV. Candidate is required to carry out minor research project on any topic of choice (based on Semester III Literature Survey Article) under the supervision of an allotted research supervisor.

The marking scheme of dissertation is as follows:

Total Marks 100

Internal (30 %)

Synopsis	Attendance	Total
20 marks	**10 marks**	**30 marks**

External (70 %)

Objective	Methodology	Review and bibliography	Results	Presentation	Viva	Total
10 marks	**10 marks**	**10 marks**	**15 marks**	**10 marks**	**15 marks**	**70 marks**

PAPER CODE- CHY 423 (A)
Polymers and Material Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to make the students aware about the structure and morphology of polymers and various techniques for the determination of molecular weight of polymers, to make students aware of the kinetics and mechanism of polymerization reactions and to expose the students to new materials.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 423(A)	Polymers and Material Chemistry	**The students will be able to-** CO130- calculate the molecular weight of polymers by different methods. CO131- compare the nature of crystal structures and morphology of polymers of various degree of crystallinity. CO132- interpret mechanism and kinetics of polymerization. CO133- elucidate the structures of metal clusters, boron cage compounds and aluminosilicates.	Interactive Lectures Discussions Tutorials Quiz Problem solving	Google Quiz Assignment Semester End Exam

CONTENTS

I Polymer Characterization 13hrs
Introduction, classification of polymers, average molecular weight, number-average and weight-average molecular weights, sedimentation and viscosity average molecular weights. Polydispersity and molecular weight distribution, practical significance of molecular weight. Measurement of molecular weights: End-group, viscosity, light scattering, osmotic and ultra-centrifugation methods**.**

II Structure and Properties 10hrs
Morphology and order in crystalline polymers: Configuration of polymer chains, crystal structure of polymers, morphology of crystalline polymers, crystallization and melting, strain-induced morphology, glass transition temperature T_g, factors affecting T_g, crystalline melting point T_m, factors affecting T_m.

III Kinetics of Polymerization 15hrs
Mechanism of stepwise polymerization, kinetics and statistics of linear stepwise polymerization, polyfunctional step-reaction polymerization: Prediction of gel point. Kinetics of free radical chain polymerization, cationic and anionic polymerization. Kinetics of copolymerization.

IV Boron Cage Compounds and Metal Clusters 10hrs

Higher boranes, carboranes**,** metalloboranes and metallocarboranes, compounds with metal-metal multiple bonds.

V Silicates and Aluminosilicates 12hrs

Classification, structure, properties and applications of naturally occurring silicates and aluminosilicates. Synthesis of pillared clays and zeolites. Characterization of clays and zeolites from measurement of surface area, surface activity pore size, distribution and interlayer spacing. Application of clays, pillared clays and zeolites with emphasis of catalysis.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Textbook of Polymer Science; Third Edition; F. W. Billmeyer; John Wiley & Sons, India, 2007.
- Polymer Science; Second Edition; V.R. Gowariker; New Age International Pvt. Ltd., New Delhi, 2015.
- Principles of Polymer Science; First Edition; P. Bahadur and N.V. Sastry; Narosa Publishing House, New Delhi, 2006.
- Material Science and Engineering; Ninth Edition; An Introduction; W.D. Callister & David G. Rethwisch, John Wiley & Sons,2014.

PAPER CODE- CHY 424 (A)
Bioinorganic Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to make students understand the role of various elements in the living system**,** to acquire basic knowledge about the structure and functions of metalloenzymes and to know about the mechanism of binding interactions of metal complexes with biomolecules and metal based drug action.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 424(A)	Bioinorganic Chemistry	**The students will be able to-** CO134-apply the principles of coordination chemistry in biological systems. CO135-explain the structures and functions of variety of metalloenzymes CO136-comprehend the importance of metals in medicine. CO137-discuss the various fundamental interactions of nucleic acids with metal ions.	Class Lecture Tutorials Quiz Problem solving	Group Discussion Quiz Assignment PowerPoint Presentation Semester End Exam

CONTENTS

I Metal Ions in Living System 14hrs

Introduction: Essential and trace elements, Principles of coordination chemistry in biological systems, HSAB concept, chelate effect, Irving Williams series, pKa values of coordination ligands, tuning of redox potential, biopolymer effects, ligand exchange rates, substitution reactions, electron transfer reactions.

Molecular mechanism – ion transport across membranes, active transport of Na-K (ion pumps). Chlorophyll and their role in photosynthesis, (Calcium cycle and quantum efficiency) PS I and PS II system.

Calcium in Biological Systems*:* Calcium in living cells, transport and regulation of Ca^{2+} ions in higher organisms, molecular aspects of intramolecular processes, extracellular binding proteins.

II Iron in Biological Systems 13hrs

Metal Storage and Transport: Structure and function of Ferritin, Transferrin, Siderophores, hemoglobin, myoglobin, hemocyanin and hemerythrin.

Electron transport proteins: Structure and function of cytochromes with special reference to cytochrome c, Iron-Sulphur proteins- Ferredoxins. biological nitrogen fixation and its mechanism, nitrogenenases, dinitrogen complexes as models for nitrogen fixation. Dioxygen model complexes of Fe, Co and Cu.

III Metalloenzymes 13hrs

Zinc enzymes: Carboxypeptidase and carbonic anhydrase, alcoholic dehydrogenase. Iron enzymes: Catalase, peroxidase and cytochrome P-450.Copper enzymes: Superoxide dismutase, xanthine oxidase, vitamin B_{12} and B_{12} coenzymes.

IV Metals in Medicine 8hr

Fe, Zn and Cu deficiency, toxicity: Cu overload and Wilson's disease, iron toxicity, toxicity of As, Cd, Hg and Pb. Metal complexes in medicines, chelation therapy, BAL, penicilamine, poly amino carboxylic acid and desferrioxamine-gold compounds, rheumatoid arthritis, Pt complexes as anticancer drug, metal complexes in radio diagnosis, MRI.

V Metal-nucleic Acid Interactions 12hrs

Basics- nucleic acid structure, fundamental interactions and reactions with nucleic acids, applications of different metal complexes that binds nucleic acids, conformational probes, metal-nucleic acid interactions with special references to zinc finger protein.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Principles of Bioinorganic Chemistry; First Edition; S. J. Lippard, J.M. Berg; Panima Publishing Corporation, New Delhi, 2005.
- Bioinorganic Chemistry; First South Asian Edition; I.Bertini, H.B.Gray, S.J.Lippard; Viva Books Pvt Ltd., New Delhi, 2008.
- Bioinorganic Chemistry; First Edition; M.Satake, Y.Mido; Discovery Publishing House, New Delhi, 2011.
- Lehninger Principles of Biochemistry; Seventh Edition; David L. Nelson, Michael M. Cox; W H Freeman,2017.

PAPER CODE- CHY 425 (A)
Supramolecular and Photoinorganic Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to acquaint the students with the host guest chemistry of supramolecules and the basics of photoinorganic chemistry.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 425(A)	Supramolecular and Photoinorganic Chemistry	**The students will be able to-** CO138-explain the fundamental concepts of host-guest interactions in supramolecules. CO139-compare various types of binding in supramolecules and differentiate different types of molecular recognition. CO140-discuss reaction conditions for different types of photoinorganic transformations. CO141-summarize physical properties of electronic excited states.	Class lectures Tutorials Group discussions Seminar Power point presentation	Written test Google Quiz Assignment Semester End Exam

CONTENTS

I Supramolecular Chemistry-I 15 hrs

Definition and development of supra molecular chemistry, nature of supramolecular interactions (ion pairing, ion-dipole, dipole-dipole, dipole-induced dipole and ion-induced dipole, van der Waals or Dispersion, hydrogen bonding, cation-π, anion-π, closed shell, π-π stacking).

Classification of host-guest compounds, pre-organisation and complementarity: Thermodynamic and kinetic effects.

Cation Binding: Complexation by crown ether, cryptands (spherical and tetrahedral recognition), spherands, lariat ethers and podands. Recognition of ammonium ions.Synthesis: Template effect and high dilution. Biological significance: Valinomycin and nonactin.

Anion Binding: Basic concepts of anion binding, cyclophanes and guanidinium-based receptors,neutral receptors: zwitterions, amide-based receptors. Biological significance: Phosphate and sulphate binding properties. Binding and recognition of neutral molecules.

II Supramolecular Chemistry-II 11 hrs

Coreceptor molecules and multiple recognition: dinuclear and polynuclear metal ion cryptates,

linear recognition of molecular length by ditopic coreceptors, heterotopic coreceptors: Cyclophane receptors, amphiphilic receptors, large molecular cages, multiple recognition in metalloreceptors.
Transport processes and carrier design: Cation, anion and coupled transport process.

III Supramolecular Chemistry-III 11 hrs

Supramolecular devices: Supramolecular photochemistry, supramolecular electronic, ionic and switching devices.
Supramolecular catalysis: Supramolecular metallocatalysis, co-catalysis, bimolecular and abiotic catalysis.

IV Photoinorganic Chemistry -I 11hrs

Photochemical laws, physical properties of the electronically exited states: Dipole moment, acid base strengths, redox potential, geometry of some electronically exited molecules, Wigner's spin conservation rule. Lifetime of excited electronic states of atoms and molecules.

V Photoinorganic Chemistry–II 12 Hrs

Photochemical reactions of octahedral complexes of Cr(III): Some properties of ligand field excited states and energy level diagrams, Photosubstitution (aquation) reactions of Cr(III) complexes.
Photosubstitution, photoisomerisation and photoredox reactions of square planar complexes of Pt(II). Photochemical splitting of water and photochemistry of $[Ru(bpy)_3]^{+2}$, TiO_2 as an important photocatalyst.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Supramolecular Chemistry: Concepts and Perspectives; First Edition; J.M. Lehn; VCH Publishers, 2014.
- Supramolecular Chemistry; Second Edition; J. W. Steed, J. L. Atwood; Wiley, New York,2009.
- Elements of Inorganic Photochemistry; First Edition; GJ. Ferraudi; John Wiley and Sons, 1988.
- Bioorganic, Bioinorganic and Supramolecular Chemistry; Third Edition; P. S. Kalsi, J. P. Kalsi; New Age International,New Delhi,2017.
- Concepts of Inorganic Photochemistry; A. W. Adamson and P. D. Fleischaur, John Wiley & Sons, 1984.
- Fundamentals of Photochemistry; Third Edition;K.K. Rohatgi-Mukherjee; New Age International (P) Ltd.,New Delhi,2007.

PAPER CODE- CHY 423 (B)
Heterocyclic Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to provide a broad introduction to heterocyclic chemistry and its nomenclature. Emphasis is given on some important heterocyclic systems, such as aziridines, oxiranes, oxetanes, benzopyrroles, benzofurans, benzothiophenes, pyrones, diazines, triazines, thiazines, and meso-ionic heterocycles. For each group, students will be acquainted with ring synthesis, chemical properties and characteristic reactions.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 423(B)	Heterocyclic Chemistry	**The students will be able to-** CO142-learn and understand the specific properties and biological activities of some important heterocycles. CO143-describe mechanisms for reactions involving heterocycles as starting materials, intermediates and products, and be able to propose syntheses of heterocycles from the major classes and assign their names.	Interactive Lectures Discussions Tutorials Quiz Problem solving	PowerPoint Presentation Written test Google Quiz Assignment Semester End Exam

CONTENTS

I Introduction and Nomenclature of Heterocycles 12 hrs
Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles.
General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in 1H NMR-spectra, empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations), heteroaromatic reactivity and tautomerism in aromatic heterocycles.

II Conformational Analysis of Non-aromatic Heterocycles 12 hrs
Strain-bond angle, torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction, stereo-electronic effects: Anomeric and related effects, attractive interactions: Hydrogen bonding and intermolecular nucleophilic-electrophilic interactions.

III Small Ring Heterocycles 12 hrs
Three-membered and four membered heterocycles: Synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes, five membered heterocycles: Synthesis

and reactions of different isomers of diazoles (pyrazoles, imidazoles), oxazoles, thiazoles, 1,2,4-triazole, oxadiazole, thiadiazole, 1,2,3,4-tetrazole.Porphyrins and applications.

IV Benzo-Fused Five-Membered Heterocycles and MesoIonic 12 hrs

Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes. Meso-ionic heterocycles: Classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications. Sydnones.

V Six Membered Heterocycles 12 hrs

With one heteroatom*:* synthesis and reactions of pyrilium salts and pyrones and their comparison with pyridinium and thiopyrylium salts and pyridones; synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones.

With two or more heteroatoms*:* Synthesis and reactions of diazines, triazines, tetrazines and thiazines. Some important macroheterocycles.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Heterocyclic Chemistry Vol. I & II; First Edition; R.R. Gupta and M. Kumar; Springer (India) Pvt. Ltd., 2011.
- Heterocyclic Chemistry; Fifth Edition; J.A. Joule and K.Mills; Wiley-Blackwell, London, 2013.
- Heterocyclic Chemistry; Third Edition; T.L. Gilchrist; Pearson Education,Delhi,2005.
- An Introduction to the Chemistry of Heterocyclic Compounds; Third Edition; R.M. Acheson; Wiley Eastern Ltd, New Delhi,1976.
- Contemporary Heterocyclic Chemistry; First Edition, G.R. Newkome and W.W. Paudler, Wiley Interscience, 1982.

PAPER CODE- CHY 424 (B)
Natural Products and Medicinal Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to describe the process of identification and isolation of natural products, their chemical synthesis, biological activities, ecological relevance and possible applications in the fields of pharmacology using selected examples. It also aims to introduce students with the fundamental concepts of drug discovery and development emphasizing specific classes of drugs.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY-424(B)	Natural Products and Medicinal Chemistry	**The students will be able to-** CO144- recognize various types of natural products along with their applications in medicinal chemistry. CO145-explain the different techniques that are used in natural products chemistry as well as their structure elucidation. CO146-describe the key concepts and strategies used during drug discovery, development and mode of action. CO147-explain the importance of quantitative structure-activity relationship (QSAR) as a potential source for rational drug design in brief.	Interactive Lectures Discussion Tutorials Problem Solving Power Point Presentation	Quiz Assignments Written Test Semester End Exam

CONTENTS

I Terpenoids and Carotenoids 12 hrs
Classification, nomenclature, occurrence, general methods of structure determination, isoprene rule; Structure determination, stereochemistry and synthesis of the following representative molecules: Citral, Geraniol, Menthol and β-Carotene.

II Alkaloids 12 hrs

Definition, nomenclature, physiological action, occurrence, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring. Structure, stereochemistry and synthesis of the following: Ephedrine, (+)-Nicotine and Morphine.

III Steroids 12 hrs

Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Structure determination and synthesis of Cholesterol, Androsterone, Testosterone, Estrone.

IV Medicinal Chemistry I 12 hrs

Introduction to drugs, discovery, development and delivery. Agonists and antagonists. Relation of Drug structure and its chemical and biological properties. Structure-activity and quantitative relationship. Drug targets.

V Medicinal Chemistry II 12 hrs

General introduction and mode of action of- antiviral, antibiotics and anti-AIDS drugs. Anti-inflammatory, analgesics, antihistamines, anti-hypertensive and anti-cancer drugs. General study of hormones, classification based on solubility and structures, mode of action of water soluble and fat-soluble messengers.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Introduction to Medicinal Chemistry: First Edition,A Gringauz, Wiley-VCH, 1996
- Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry; Twelfth Edition,Wolters Kluwer India Pvt. Ltd., 2010.
- An Introduction to Drug Design; Second Edition, S. N. Pandeya and J.R. Dimmock, New Age International, 2019.
- Burgers's Medicinal Chemistry and Drug Discovery; Sixth Edition, D.J. Abraham, Wiley-Blackwell, 2003.
- Goodmann and Gilman's Pharmacological Basis of Therapeutics; Thirteenth Edition, Laurence L. Brunton, Mc-Graw Hill, 2017.
- The Organic Chemistry of Drug Design and Drug Action; Third Edition, R. B. Silverman, Academic Press, 2014.
- Strategies for Organic Drug Synthesis and Design; Second Edition, D. Lednicer, Wiley-Blackwell, 2008

PAPER CODE- CHY 425 (B)
Biomolecules and Bioorganic Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to endow students with the knowledge of the structure-function relationship of biomolecules, and their importance with regard to maintenance and perpetuation of the living systems.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 425(B)	Biomolecules and Bio-organic Chemistry	**The students will be able to-** CO148-demonstrate remarkable properties and functions of enzymes and illustrate mechanisms of enzyme catalyzed reactions. CO149-describe major pathways of carbohydrate metabolism. CO150-recognize the structures of amino acids and elucidate common pathways of amino acid catabolism. CO151-summarize the functions of proteins and identify the influence of the three-dimensional shape and subunits of a protein on its function. CO152-analyse the role of fat in energy production, membrane synthesis, and production of bioactive molecules and describe the structure, biosynthesis, oxidation and storage of fatty acids. CO153-learn the structure and functions of RNA and DNA. CO154-correlate how the biomolecules such as proteins, carbohydrates, lipids, nucleic acids are made from the simple precursors. CO155-interpret the structure-function relationships of the proteins, carbohydrates, lipids, and nucleic acids.	Class lectures Tutorials Group discussions Question preparation: Subjective type- Long answer Short answer Objective type- Multiple choice questions One answer/two answer type questions Assertion and reasoning	PowerPoint Presentation Written test Google Quiz Assignment Semester End Exam

CONTENTS

I Enzymes 14hrs

Remarkable properties of enzymes like catalytic power, specificity and regulation, nomenclature and classification. Fischer's lock and key and Koshland's induced fit hypothesis. Enzyme kinetics: Michaelis-Menten and Lineweaver-Burk plots, Bisubstrate reactions. Enzyme inhibition. Factors affecting enzyme catalysis. Examples of some typical enzyme mechanisms for Chymotrypsin, Ribonuclease, Lysozyme, & Carboxipeptidase A.
Affinity labeling and enzyme modification by site-directed mutagenesis.

II Carbohydrate Metabolism 12 hrs

Structure & classification of carbohydrates. Glycolysis, fate of pyruvate under anaerobic conditions, citric acid cycle, oxidative phosphorylation (electron transport system), gluconeogenesis and glucogenolysis, C4 pathway, pentose phosphate pathway and photosynthesis: C3, C4 & CAM pathway.

III Protein Metabolism and Disorders 12 hrs

Classification of amino acids. Degradation of amino acids (C3, C4, C5 family), urea cycle, uric acid and ammonia formation. Proteins (Structure and Functions): primary, secondary, tertiary and quaternary structure. Extraction and purification techniques.

IV Lipids 12 hrs

Classification and nomenclature of Fatty acids, Classification, Structure and functions of lipids. Biosynthesis of saturated and unsaturated fatty acids, Ketone bodies, membrane lipids-cholesterol, phospholipid and glycolipid, biosynthesis of fat soluble vitamins, biosynthesis of Eicosonoids (prostaglandin, leucotriens and thromboxane).Metabolism of Lipid and fat bodies: Beta-oxidation and channelling of the products to ATP production: minor pathway of fatty acid oxidation: alpha and omega oxidation.

V Nucleic Acids 10 hrs

Chemical and enzymatic hydrolysis, structure and functions of DNA, RNA (m-RNA, t-RNA, r-RNA), an overview of gene expression (replication, transcription and translation), genetic code (origin, Wobble hypothesis and other important features).

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Bioorganic Chemistry: A Chemical Approach to Enzyme Action; Third Edition, Herman Dugas, Springer, New York,2012.
- Lehninger Principles of Biochemistry International Edition; Seventh Edition; David L. Nelson and Michael Cox; W.H. Freeman, 2017.
- Biochemistry; Ninth Edition; L. Stryer; W.H. Freeman and Company, 2019.
- Biochemistry; J. David Rawn, Panima Publishing Corporation, New Delhi, 2004.
- Biochemistry; Fourth Edition; D. Voet; John Wiley and Sons, 2011.
- Outline of Biochemistry; Fifth Edition; E.E. Conn and P.K. Stumpf; Wiley Eastern Ltd., New Delhi, 2006.
- Chemistry and the Living Organism; Sixth Edition; M.M. Bloomfield; John Wiley and Sons, 1995.

PAPER CODE- CHY 423 (C)
Advanced Electrochemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to acquaint the students with the advanced aspects of electrochemistry so that they are able to understand the mechanism and processes of battery, fuel cell, corrosion and electro-catalysis.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 423(C)	Advanced Electrochemistry	**The students will be able to-** CO156-compare different batteries and select an appropriate one as per requirement. CO157-illustrate the concept of corrosion, corrosion inhibition and apply thermodynamics to discuss the stability of a metal. CO158-discuss the principle of different type of fuel cells, their properties and applications. CO159-define the concept of Hydrogen economy and different aspects related to Hydrogen. CO160- explain the concept, mechanism, types and factors affecting electrocatalysis. CO161-describe some electrochemical phenomenon occurring in the environment.	Class lectures Tutorials Group discussions Question preparation: Subjective type- Long answer Short answer Objective type- Multiple choice questions One answer/two answer type questions Assertion and reasoning	PowerPoint Presentation Written test Google Quiz Assignment Semester End Exam

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CONTENTS

I Electrochemical Energy Storage 12 hrs

Properties of electrochemical energy devices: Discharge plot, Ragone plot, measure of battery performance, charging and discharging of batteries, electrochemical capacitors as energy storage device, storage density**,** energy density.

Classical Batteries: (i) Lead Acid (ii) Nickel –Cadmium (iii) Zinc – Manganese dioxide

Modern Batteries (i) Zinc- Air (ii) Nickel – Metal Hydride (iii) Lithium Battery (iv) Lithium ion Battery.

II Corrosion 12 hrs

Electrochemical corrosion of metals, thermodynamics and stability of metals, potential –pH (or Pourbaix) diagrams, uses and abuses, corrosion current and corrosion potential: Evans diagram.

Measurement of corrosion rate: Weight loss method and electrochemical method.

Inhibition of corrosion: Cathodic and anodic protection (i) by addition of substances to the electrolytic environment (ii) by charging corroding metal from external source, organic inhibition: The fuller story, green inhibitors.

Passivation: Nature of the passive layer, structure of the passive film, methods of passivation, depassivation, localized corrosion.

III Fuel Cells 12 hrs

Electrochemical generators (Fuel Cells): Efficiency, kinetics of fuel cell reactions. Types of fuel cells: Alkaline fuel cell, phosphoric acid fuel cell, high temperature fuel cell, solid polymer electrolyte fuel cell, direct MeOH fuel cell, molten carbonate fuel cell, solid oxide fuel cell, applications of fuel cells.

Energy options: Hydrogen economy, introduction, hydrogen production, hydrogen transmission, storage and distribution, hydrogen fueled equipments, local electricity, production from hydrogen, hazards and safety aspects of hydrogen.

IV Electrocatalysis 12 hrs

Chemical catalysis and electrocatalysis, cathodic and anodic electro catalysis, electrocatalysis and adsorption effects, mechanism of electrocatalysis, volcanoes, metal electrodes-influence of the nature of the metal, influence of surface state and structure, highly dispersed metal catalyst, binary and multicomponent metal catalysts (metal alloys and atoms), non-metallic catalysts, metal complexes with organic ligands.

Bio catalysis: Enzymes, immobilization, practical application of enzymes as electrode.

V Environmentally Oriented Electrochemistry and Electrochemical Sensors 12hrs

Environmentally oriented electrochemistry: Electrochemistry of water splitting, superelectrolyzers, photo electrochemical splitting of water, solar hydrogen production, fixing of CO_2, mechanism of CO_2 reduction, photochemical reduction of CO_2, removal of wastes. Electrochemical decontamination of soil.

Electrochemical Sensors: Enzyme based sensors, affinity biosensors, gas sensors.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Modern Electrochemistry; Vol. I & II, Second Edition; J. O'm. Bockrisand K.N. Reddy; Kluwer Academic Press, New York, 2001.
- Fundamentals of Electrochemistry; Second Edition; V. S. Bagotsky; John Wiley and Sons, 2006.
- Advanced Physical Chemistry; Eighteenth Edition; J. N. Gurtu and A. Gurtu; Pragati Prakashan, Meerut 2015.
- Topics in Pure and Applied Electrochemistry; S. K. Rangarajan; SASET Publication, Karaikudi, 1975.
- Fuelcell Handbook; Seventh Edition; US Department of Energy, National Energy Technology Laboratory, West Virginia, 2004.
- Analytical Electrochemistry; Third Edition; J Wang; Wiley VCH, 2006.

PAPER CODE- CHY 424 (C)
Solid State and Nanotechnology
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to expose the students with the fascinating area of solid-state chemistry and super conductors. Students will acquire knowledge to use various diffraction methods in structural analysis and to understand the different aspects of nano materials.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 424(C)	Solid State and Nanotechnology	**The students will be able to-** CO162-illustrate the concept of solid-state reaction and different methods used in preparation of inorganic solids. CO163-perform structural analysis of crystals with the help of XRD measurements. CO164-describe properties and applications of semiconductors and explain the concept of Superconductivity CO165-discuss various fabrications methods of nanomaterials. CO166-explain various properties and applications of nanomaterials.	Class lectures Tutorials Group discussions Question preparation Subjective type Long answer Short answer Objective type Multiple choice questions One answer/two answer type questions Assertion and reasoning	Written test Google Quiz Assignment Semester End Exam

CONTENTS

I **Solid State Reactions and Preparative Methods of Inorganic Solids** **10 hrs**
Introduction to the solid state reactions, electrical, optical, magnetic and thermal properties of inorganic materials, general principles, experimental procedures, co-precipitation as a precursor to solid state reactions.
Preparative methods of inorganic solids: Crystallization of solutions, glasses, gels and melts, vapour phase transport methods, electrochemical reduction methods, preparation of thin films, growth of single crystals, high pressure and hydrothermal methods.

II **X-ray Diffraction** **12 hrs**
Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, Miller indices, identification of unit cells from systematic absences in diffraction pattern, structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem; procedure of X-ray structure analysis.
Cryo-electron microscopy, electron diffraction and neutron diffraction (brief idea).

III Electronic Properties and Band Theory 11 hrs

Semiconductors: Influence of doping on band gap, applications, p-n junction, photovoltaic cell and solar conversion.

Optical properties: Optical reflectance, photoconduction-photoelectric effects, principle of LED, LCD.

Superconductivity: Meissner effect, critical temperature and critical magnetic field – type I and II superconductors, ternary oxides: structure of 123 oxides (Y-Ba-Cu-O), BCS theory of superconductivity, Cooper pair electron.

IV Introduction to Nanomaterials 13 hrs

Emergence in nanotechnology, types of nanomaterials, zero dimensional, one dimensional, two dimensional, advanced nanomaterials.

Fabrication methods: Bottom up and top down approach, solution phase and vapor phase synthesis,

Physical methods- Physical vapour deposition (evaporation, sputtering and plasma processing methods), chemical vapour deposition, epitaxial growth method, ball miling, lithography.

Chemical methods- Sol-gel process, reduction method, self-assembly method, coprecipitation, microemulsion, solvothermal, microwave synthesis, evaporation, template synthesis, sonochemical synthesis, radiation assisted synthesis, chemical etching.

Biological methods-Synthesis using microorganism, biological templates, plants and plant extracts.

V Properties and Applications of Nanomaterials 14 hrs

Properties of nanomaterials: Structural properties, electronic properties, magnetic properties, electrical properties, optical properties, mechanical properties. Surface energy controlling the different properties of nanomaterials.

Stabilization of nanoparticles: Electrostatic and steric stabilization of nanoparticles, quantum confinement effect, nanocatalyst.

Carbon nanomaterials: Fullerenes, graphenes, nanotubes.

Applications and social impact: Energy-solar photovoltaics, solar thermal collectors, fuel cells, hydrogen storage, defense, nanomedicines.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Solid State Chemistry and its Applications; Second Edition, A.R. West; Wiley, Singapore, 2014.
- Principles of the Solid State; First Edition; H.V. Keer; New Age International (P) Limited, New Delhi, 2017.
- Solid State Chemistry; Second Revised Edition; D.K. Chakrabarty; New Age International (P) Limited, New Delhi, 2011.
- Introduction to Nanotechnology; First Edition; R. Singh and S. M. Gupta; Oxford University Press, 2016.
- An Introduction to Nanomaterials and Nanoscience; A. K. Das, M. Das; CBS Publishers and Distributors Private Limited, 2014.

PAPER CODE- CHY 425 (C)
Advanced Chemical Kinetics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
Student will acquire knowledge of kinetics of some special reactions and different techniques of fast reaction. They will be able to understand the different type of PES and molecular reaction dynamics.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 425(C)	Advanced Chemical Kinetics	**The students will be able to-** CO167-interpret methods for the kinetic studies of fast reactions. CO168-establish rate law for catalytic reactions using steady state approximation. CO169-interpret a reaction coordinate diagram (potential energy surface) and determine reaction pathway. CO170-explain kinetics of surface reactions and photochemical reactions.	Class lectures Tutorials Group discussions Question preparation Subjective type Long answer Short answer Objective type Multiple choice questions One answer/two answer type questions Assertion and reasoning	Power point Presentation Group discussion Quiz Written test Semester End Exam

CONTENTS

I Kinetics of Some Special Reactions 12 hrs

Kinetics and mechanism of atom and radical combination reactions, kinetics of solid-state reactions, polymerization reaction, electron transfer reactions.

Fast reactions: Introduction, study of different techniques for fast reactions, flow techniques, relaxation techniques (including derivations), flash photolysis, shock tubes.

II Kinetics of Catalyzed Reactions 12 hrs

General catalytic mechanism: Equilibrium treatment, steady state treatment, activation energies for catalyzed reactions.

Acid-base catalysis: Mechanism, catalytic activity and acid base strength, acidity functions.

Enzyme catalysis: Michaelis-Menten mechanism, influence of substrate concentration, influence of pH, influence of temperature, transient phase kinetics.

Micellar catalysis, phase transfer catalysis, kinetics of inhibition.

III Reactions on Surfaces 12 hrs

Competitive adsorption, non-ideal adsorption, thermodynamics and statistical mechanics of adsorption, structures of solid surfaces and adsorbed layers, mechanism of surface reactions, unimolecular surface reactions, bimolecular surface reactions, transition state theory of surface reactions.

IV Molecular Reaction Dynamics 12 hrs

Molecular dynamical calculations: Reaction of H + H_2, reaction of Br + H_2. Chemiluminescence. Potential energy surfaces: Selective enhancement of a reaction, disposal of excess energy, gradual and sudden surfaces, influence of rotational energy. Molecular beams: Principle of crossed molecular beams, molecular encounter and principle parameters e.g. impact parameter, collision cross-section, reaction cross section and relation between reaction cross section and reaction rate (single velocity).

V Photophysical Chemistry 12 hrs

Photochemical reactions: Photochemical primary process, law of photochemical equivalence, fate of the excited molecules. Photophysical kinetics of unimolecular processes, delayed fluorescence, effect of temperature, bimolecular collisions in gases and solutions, mechanism and kinetics of quenching: Stern-Volmer equation, concentration dependence of quenching and excimer formation.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Chemical Kinetics; Third Edition; K.J. Laidler; Pearson Education Private Limited, Singapore, 2013.
- Kinetics and Mechanisms of Chemical Transformations; First Edition; J. Rajaram and J.C. Kuriacose; Macmillan Publisher India Ltd., New Delhi, 2011.
- Fundamentals of Photochemistry; Third Edition, K.K. Rohatgi-Mukherjee; New Age International (P) Limited, Publishers, Delhi, 2017.
- Chemical Kinetics and Reaction Dynamics; First Edition; S. K. Upadhyay; Springer Netherlands, 2010.

PAPER CODE- CHY 426 (A/B/C)
Computational Chemistry
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives :
The course aims to give the knowledge of different methods, techniques and basic concept of computational chemistry so that the students will be able to use computational chemistry to solve inorganic chemistry, organic chemistry and physical chemistry.

Course Outcomes (Cos):

COURSE		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
CHY 426	Computational Chemistry	**The students will be able to-** CO171-differentiate between molecular mechanics, semi emperical, ab initio and correlation methods. CO172-explain different steps in a model reaction CO173-know strength and weaknesses of DFT method. CO174-determine some properties of molecules such as basicity, electron affinity, ionization potential, 1H NMR chemical shift.	Class lectures Tutorials Group discussions Question preparation Subjective type Long answer Short answer Objective type Multiple choice questions One answer/two answer type questions Assertion and reasoning	Assignments Written Test Semester End Exam

CONTENTS

I Molecular Mechanics, Semi-Empirical Methods and Electron Correlation Methods **12hrs**

Introduction, Scope of computational chemistry.
Molecular mechanics / force field methods, the force field energy, advantages and limitations of molecular mechanics methods.
Electronic Structure Methods: The Schrödinger equation, molecular Hamiltonian, Born-Oppenheimer approximation, self-consistent field theory, Koopmans' theorem, Hartee-Fock theory, restricted and unrestricted Hartree-Fock, the variation principle, SCF techniques, Rootham-Hall equation, semi-empirical methods: CNDO, MINDO, MNDO, AM1, MNDO-PM3, limits and advantages of semi-empirical methods.
Excited slater determinants, Configuration Interaction (CI), Multi-Configuration Self-Consistent Field (MCSCF), Complete Active Space Self-Consistent Field (CASSCF), many-body perturbation

theory, Møller-Plesset perturbation theory, Coupled Cluster (CC) methods, density functional theory, local density methods, gradient corrected methods, hybrid methods.

II Basis Sets, Geometry Optimization and Frequency Calculations 12hrs

Slater and gaussian type orbitals, polarization and diffuse functions, split-valence sets, classification of basis sets, even- and well-tempered basis sets, pople style basis sets, Dunning-Huzinga basis sets, correlation consistent basis sets, extrapolation procedures, effective core potential basis sets.

Introduction to Potential Energy Surface(PES), local minimum, global minimum, and saddle point, convergence criteria, transition structures, frequency calculations, zero-point corrections, thermo chemistry, Intrinsic Reaction Coordinate (IRC) analysis, calculation of activation and reaction enthalpies, Some illustrative examples: Ethylene, 1,3-butadiene, 1-fluoropropane, vinyl alcohol, isodesmic and isogyric reactions, natural bond orbital analysis.

III Some Applications of Computational Chemistry in Organic Chemistry 16 hrs

Relative stabilities of cyclopropane, oxirane, azirane and phosphirane; aromaticity indices: Julg concept, Aromatic Stabilization Energies (ASE), Nucleus Independent Chemical Shift (NICS) values, magnetic susceptibility exaltation, ^{1}H NMR chemical shift values of cyclopropenium cation, cyclopentadienyl anion, cyclobutadiene (antiaromatic) and benzene, electron affinity, electrophilicity and nucleophilicity indices, chemical potential.

Application of DFT to Thermodynamic properties, Geometrics, Charges (e.g.- glycine cation), dipole moment, electrostatic potential (acetyl chloride & acetamide), gas phase acidities and pKa values, supramolecular chemistry (quinhydrone complex), dye chemistry.

IV Applications to DFT in Inorganic Chemistry 12 hrs

The calculation of NMR parameters in transition metal complexes, excitation energies of metal complexes with Time-dependent DFT, application of Hybrid-DFT to Homogenous catalysis, DFT computation of relative spin – state and energetics of transition metal compounds.

V Applications of DFT in Physical Chemistry 8hrs

Phase transformation in ZnS under Hydrostatic pressure, optical properties, structural properties, phase diagram.

BOOKS RECOMMENDED:

SUGGESTED READINGS:

- Exploring Chemistry with Electronic Structure Methods; Third Edition; J. B. Foresman and A. Frisch, Gaussian, 2015.
- Ab Initio Molecular Orbital Theory; First Edition, W.J. Hehre, L. Radom, P.R. Schleyer and J. Pople; John Wiley Interscience, 1986.
- Computational Chemistry; First Edition, A.C. Norrin; John Wiley& Sons, 1981.
- Introduction to Computational Chemistry; Second Edition, F. Jensen; John Wiley &Sons, 2007.