CURRICULUM & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

MASTER OF SCIENCE (M.Sc.)

(2 Year Postgraduate Degree Programme)

IN

CHEMISTRY (H)

[w. e. f. 2020-21]

FACULTY OF SCIENCE & HUMANITIES
SRM UNIVERSITY DELHI-NCR, SONEPAT
Plot No.39, Rajiv Gandhi Education City, P.S. Rai,
Sonepat
Haryana-131029

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Delhi-NCR, Sonepat, Haryana aims to emerge as a leading world-class university that creates and disseminates knowledge upholding the highest standards of instruction in Medicine & Health Sciences, Engineering & Technology, Management, Law, Science & Humanities. Along with academic excellence and skills, our curriculum imparts integrity and social sensitivity to mould our postgraduates who may be best suited to serve the nation and the world.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Promote excellence in educational & skill development processes.
- Continue to build productive international alliances.
- Explore optimal development opportunities available to students and faculty.
- Cultivate an exciting and rigorous research environment.

DEPARTMENT OF CHEMISTRY

VISION

Department of Chemistry is committed to provide Intellectual, Innovative &Motivational surroundings to students and faculty members. Department is focused to contribute for academic, scientific, research and experimental knowledge through excellence and to produce scientist, researchers and bureaucrats. Department wants to strive and achieve reputation of seeking attention of Government of India and use of others to be invited to provide services on the subjects involving Chemistry and allied areas.

MISSION

- To improve the problem-solving capability of students through continual learning to produce quality Chemists, Scientists, Academic intellectuals etc. in the field of Science and Technology.
- To bridge the gap between industry and academia by imparting technical/experimental knowledge, along with its application in the practical world.
- To encourage innovation through multidisciplinary research and development activities.
- To inculcate human values and ethics into students to serve the society and nation, in all possible ways.
- Personality development of students is also given priority simultaneously.

PROGRAM REQUIREMENT

General Education Requirements: Applied Science and Humanities (ASH)

Basic Science Requirements: Fundamental Sciences (FS) Core Sciences (ES) through regular/online mode

Disciplinary Requirements comprising of:

Department Name: Department of Chemistry-Core courses (through regular/online mode)

Department Name: *Department of Chemistry/Mathematics/CSE*-Electives (through regular/online mode)

Department Name: *Department of Chemistry*-Open Electives (through regular/online mode)

Practical and Research component:

1. Regular Practical and Research
2. Summer Internships
3. Specialized courses through the Study Abroad program
4. Minor and Major Project
5. Industry internship through the semester.

SEMESTER-I

Code	Category	Course	L	T	P	C
Theory						
20CY-301	B	Inorganic Chemistry-I (Co-ordination and rare earth metals)	**4**	**0**	**0**	**4**
20CY-303	B	Organic Chemistry-I (GOC and Stereochemistry)	**4**	**0**	**0**	**4**
20CY-305	B	Physical Chemistry-I (Quantum Chemistry and Chemical kinetics)	**4**	**0**	**0**	**4**
20CY-307	P	GE-I	**4**	**0**	**0**	**4**
Practical						
20CY-309	B	Inorganic Chemistry Practical –I	**0**	**0**	**4**	**2**
20CY-311	B	Organic Chemistry Practical -I	**0**	**0**	**4**	**2**
20CY-313	B	Physical Chemistry Practical – I	**0**	**0**	**4**	**2**
Total			**16**	**0**	**12**	**22**
Total Contact Hours			**330**			

SEMESTER-II

Code	Category	Course	L	T	P	C
Theory						
20CY-302	B	Inorganic Chemistry-II (Organometallic Chemistry)	**4**	**0**	**0**	**4**
20CY-304	B	Organic Chemistry-II (Organic Spectra and Reagents)	**4**	**0**	**0**	**4**
20CY-306	B	Physical Chemistry-II (Thermodynamics and Electrochemistry)	**4**	**0**	**0**	**4**
20CY-308	P	GE -II	**4**	**0**	**0**	**4**
Practical						
20CY-310	B	Inorganic Chemistry Practical-II	**0**	**0**	**4**	**2**
20CY-312	B	Organic Chemistry Practical -II	**0**	**0**	**4**	**2**
20CY-314	B	Physical Chemistry Practical -II	**0**	**0**	**4**	**2**
Total			**16**	**0**	**12**	**22**
Total Contact Hours			**330**			

SEMESTER-III

Code	Category	Course	L	T	P	C
Theory						
20CY-401	B	Structure and Mechanism in organic chemistry	**4**	**0**	**0**	**4**
20CY-403	B	Inorganic and Physical Spectroscopy	**4**	**0**	**0**	**4**
20CY-405	B	Bio-Inorganic and Bio-Organic Chemistry	**4**	**0**	**0**	**4**
20CY-407	B	Photochemistry and Pericyclic Chemistry	**4**	**0**	**0**	**4**
20CY-409	P	DSE-I	**4**	**0**	**0**	**4**
Practical						
20CY-411	B	Chemistry Practical III	**0**	**0**	**4**	**2**
20CY-413	B	Chemistry Practical IV	**0**	**0**	**4**	**2**
Total			**20**	**0**	**8**	**24**
Total Contact Hours			**360**			

SEMESTER-IV

Code	Category	Course	L	T	P	C
Theory						
20CY-402	B	Group Theory	**4**	**0**	**0**	**4**
20CY-404	B	Natural Products and Protecting Agents	**4**	**0**	**0**	**4**
20CY-406	B	Chemistry in Industry and Environment	**4**	**0**	**0**	**4**
20CY-408	P	DSE-II	**4**	**0**	**0**	**4**
Practical						
20CY-410	B	Chemistry Practical -V	**0**	**0**	**4**	**2**
20CY-412	B	Chemistry Practical -VI	**0**	**0**	**4**	**2**
20CY-414	P	Project	**6**	**0**	**0**	**6**
Total			**22**	**0**	**8**	**26**
Total Contact Hours			**390**			

SUMMARY OF CREDITS

Category	I Sem	II Sem	III Sem	IV Sem	Total	%
G (General)						
B (Basic Science)	18	18	20	16	72	76.60
E (Engineering Science)						
P (Professional)	4	4	4	10	22	23.40
Total	22	22	24	26	94	100

EVALUATION SCHEME

INTERNAL EVALUATION (THEORY)

Assessment	Internal Assessment				Assignment/Presentation/ Class participation	Total
	UNIT-I	UNIT-II	UNIT-III	UNIT-IV		
Marks	10	10	10	10	10	50

INTERNAL EVALUATION (PRACTICAL)

Assessment	Daily Assessment/Observation	Assignment Submission/Discussion	Programs performed during Internal practical Examinations	Viva-Voce	Total
Marks	15	15	10	10	50

EXTERNAL EVALUATION (THEORY)

Assessment	End Semester Examination	Total
Marks	100	Will be scaled in 50

EXTERNAL EVALUATION (PRACTICAL)

Assessment	Record File	Programs performed during External Practical Examinations	Written Work	Viva- Voce	Total
Marks	15	15	10	10	50

Note:

1. The evaluation scheme may change as per the university guidelines.
2. Evaluation scheme of Industrial training may vary department wise.
3. Evaluation scheme project/minor project may vary department wise.
4. Department are advised to add the evaluation scheme in their respective curriculum.

PROGRAM OBJECTIVE

Degree is awarded to candidates who have completed the course and who have met the assessment criteria for all written, major/minor projects and practical examination/assignments. The overall assessment aims for each topic are that candidates should be able to:

- Grasp the concepts while teaching in classes
- Interpret and analyze the questions
- Bridge the multiple concepts of various topics via numerical and Practicals/Project
- Extract critical knowledge from the comprehensive topics.
- Ability to write & review of scientific articles

PROGRAM OUTCOME

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On successful completion of this programme, students will:

- Have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistry
- Think critically and analyze chemical problems.
- Present scientific and technical information resulting from laboratory
- Should broaden their professional foundations through activities such as teaching, internships, and fellowships
- Use technologies/instrumentation to gather and analyze data.
- Should be able to communicate scientific results in writing and in oral presentation.
- Should acquire the basic tools needed to carry out independent chemical research. Students should become proficient in their specialized area of chemistry and successfully complete an advanced research project.
- Will be able to describe the common methods of spectroscopic and chromatographic analysis, and discuss how they can be applied to pharmaceuticals

LIST OF OPEN ELECTIVES

Code	Category	Course	L	T	P	C
Open Elective-I						
20CY-307/308	P	Mathematics for chemists	**4**	**0**	**0**	**4**
20CY-307/308	P	Computers for Chemists	**4**	**0**	**0**	**4**
Open Elective-II						
20CY-307/308	P	Biology for Chemists	**4**	**0**	**0**	**4**
20CY-307/308	P	Intellectual Property rights	**4**	**0**	**0**	**4**

LIST OF MODULE ELECTIVES

Code	Category	Course	L	T	P	C
Departmental Elective-I						
20CY-408/409	P	Polymer Science & Medicinal Chemistry	**4**	**0**	**0**	**4**
20CY-409/408	P	Nuclear Chemistry & Solid State	**4**	**0**	**0**	**4**
Departmental Elective-II						
20CY-409/408	P	Green Chemistry	**4**	**0**	**0**	**4**
20CY-409/408	P	Analytical Chemistry	**4**	**0**	**0**	**4**
20CY-409/408	P	Pharmaceutical Chemistry	**4**	**0**	**0**	**4**

Course Code-20CY-301	Subject Name-Inorganic Chemistry-I (Co-ordination and Rare earth metals)	L	T	P	C
		4	4	0	4
Course Category-B	Pre-requisite-				
	Co-requisite-20CY-301				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand bonding, electronic spectra pattern in coordination compounds.
2. To equip students to understand the various mechanisms operative in inorganic ring complexes during substitution and in electron transfer reactions.
3. To understand the nature of metal ligand equilibria in solution.

UNIT	Course contents	Contact Hours
Unit-I	**Theories of Bonding in Co-ordination Complexes** Valence bond theory and limitations, Crystal field theory, splitting of d-orbitals in cubic, octahedral, tetragonal, tetrahedral and square planar ligand environments. Structural consequences of splitting of d-orbitals, Jahn-Teller theorem, trends in ionic radii, lattice energy. Structure of spinel. MOT with σ and π bonding.	15
Unit-II	**Electronic Spectra of Transition Metal Complexes** Spectroscopic ground states, correlation and spin-orbit coupling in free ions for 1^{st}series of transition metals, Orgel diagrams for transition metal complexes (d^1–d^9states) calculation of Dq, B and ß parameters, charge transfer spectra of complexes (both metal to ligand and ligand to metal).	10
Unit-III	**Reaction Mechanism of Transition Metal Complexes - I** Reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism. **Reaction Mechanism of Transition Metal Complexes -II** Substitution reaction in square planar complexes, the trans-effect, mechanism of the substitution reactions. Redox reactions, electron transfer reactions, outer sphere type reactions, inner sphere type reactions. **Metal-Ligand Equilibria in Solution**	20

	Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand.	
Unit-IV	**Lanthanides** Extraction & applications, color and spectra, magnetic properties, Binary & Ternary compounds, lanthanide contraction, Use of lanthanide compounds as shift reagents. **Actinides** General properties, oxidation states, applications, color and spectra and magnetic properties.	15

LEARNING OUTCOME:

1. Students should be able to apply various theories of coordination compounds to explain their properties.
2. Students should be able to sketch various reaction mechanisms for synthetic inorganic chemistry.
3. Students should be able to correlate between inorganic compounds containing d- and f-block elements of the periodic table as the central metal ion and their properties.

Learning Resources	
Text Books	1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley. 2. Inorganic Chemistry, J.E. Huheey, HarperCollins. 3. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon.
Reference Books	4. Introduction to ligand fields, B.N. Figgis, Wiley Eastern-IIed. **5.** Lee, J.D. *Concise Inorganic Chemistry.*

		L	T	P	C
Course Code-20CY-303	**Subject Name-Organic Chemistry-I (GOC and Stereochemistry)**	**4**	**4**	**0**	**4**
Course Category-B	**Pre-requisite –**				
	Co-requisite-20CY-303				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To impart advanced knowledge of reactive intermediates, stereochemistry of organic compounds.
2. To acquire knowledge on reaction mechanism & structure and reactivity involved in organic molecules

UNIT	Course contents	Contact Hours
Unit-I	**Organic intermediates** Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of carbocations, carbanions, Free radicals, Carbenes, Nitrenes and Benzyne. **Aromaticity** Benzenoid and nonbenzenoid compounds, Hückel's rule, energy level of molecular orbitals, annulenes, anti-aromaticity and homo-aromaticity.	15
Unit-II	**Stereochemistry** Nomenclature systems D&L, R&S and E&Z, CIP rules. Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars. Elements ofsymmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, asymmetric synthesis (basic principle). Methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes); Stereochemistry of the compounds containing nitrogen and phosphorus.	15

Unit-III	**Conformational analysis** Conformational analysis of cyclohexanone, effect of conformation on reactivity of acyclic and cyclic compounds. Stereochemistry of nitrogen containing compounds, strain and their consequences in small ring heterocycles, conformation of six membered heterocyles. Barrier to ring inversion and pyramidalin version and 1,3-diaxial interactions.	10
Unit-IV	**Reaction Mechanism: Structure and Reactivity** Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Hard and soft acid and bases; Effect of structure on reactivity – resonance and field effects, steric effect. The Hammett equation and linear free energy relationship, substituent and reaction constants.	20

LEARNING OUTCOME:

1. Students should be able to illustrate the symmetry and chirality in the molecules, their spatial arrangement, properties and reactivity of stereoisomers, importance of the configuration of chiral organic compounds.
2. Students should be able to analyze the formation, reactivity and stability of reactive intermediates.
3. Students should be able to interpret the reaction mechanism & structure and reactivity involved in organic molecules.

Learning Resources	
Text Books	1. Advanced Organic Chemistry, F.A. Carey and R.J. Sundburg, Plenum. 2. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall. 3. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International. 4. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

Reference Books	5. Structure and Mechanism in Organic Chemistry, C.K. Ingold, CBC Publisher & Distributors, 1995. 6. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley. 7. Stereochemistry of Organic Compounds, E. L. Eliel and S. H. Wilen, Wiley Inter science. 8. Basic stereochemistry of organic molecules, S Sengupta, Book Syndicate Pvt. Ltd., Kolkata Advanced Organic Chemistry: Reaction Mechanism, Reinhard Bruckner, Harcourt 9 India) Pvt. Ltd. 9. Organic reaction Mechanism, V K Ahluwalia and R K Prasher, Narosa Publishing House.

		L	T	P	C
Course Code-20CY-305	**Subject Name: Physical Chemistry-I (Quantum Chemistry and Chemical Kinetics)**	**4**	**4**	**0**	**4**
Course Category-B	**Pre-requisite –**				
	Co-requisite– 20CY-305				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To make students understand the limitations of classical mechanics and the need of quantum chemistry.
2. To familiarize them with postulates of quantum chemistry and apply the same to derive equations for various models and hydrogen atoms.
3. To highlight applications of fundamental concepts of chemical kinetics

UNIT	Course contents	Contact Hours
Unit-I	**Quantum Mechanics I** Introduction to Quantum mechanics Postulates of Quantum Mechanics; formulation of Schrodinger wave equation; Max-Born interpretation of and the Heisenberg's uncertainty principle; Quantum mechanical operators and their commutation relation, Hermitian operators, (elementary ideas, quantum mechanical operator for linear momentum and angular momentum as Hermitian operator). The average value of the square of Hermitian operators; commuting operators and uncertainty principle(x & p; E & t); Schrodinger wave equation for a particle in one and three dimensional box; evaluation of average position, average momentum and determination of uncertainty in position and momentum and hence Heisenberg's uncertainty principle, pictorial representation of the wave equation of a particle in one dimensional box and its influence on the kinetic energy of the particle in each successive quantum level, lowest energy of the particle.	15
Unit-II	**Quantum Mechanics II** Schrodinger wave equation for a particle in a three dimensional box and the concept of degeneracy of energy levels. Schrodinger wave equation for linear harmonic	10

	oscillator, solution by polynomial method, zero point energy and its consequence. Schrodinger wave equation for two and three dimensional rigid rotor, energy of rigid rotor, selection rule space quantization; Schrodinger wave equation for hydrogen atom, separation of variable in polar spherical coordinates and its solution. Principle, azimuthal and magnetic quantum numbers and the magnitude of their values, probability distribution function, radial distribution function and shape of atomic orbitals (s, p & d).	
Unit-III	**Chemical Kinetics I** Effect of temperature on reaction rates, Rate law for opposing reactions of 1^{st} order and 2^{nd} order, Rate law for consecutive 1^{st} order reactions, Collision theory of reaction rates and its limitations, steric factor, Activated complex theory, Ionic reactions: single and double sphere models, influence of solvent and ionic strength, the comparison of collision and activated complex theory.	20
Unit-IV	**Chemical Kinetics II** Chain reactions: hydrogen – bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane. Photochemical reactions (hydrogen-bromine & hydrogen-chlorine reactions). General treatment of chain reactions (ortho–para hydrogen conversion and hydrogen – bromine reactions), apparent activation energy of chain reactions, chain length, Rice-Herzfeld mechanism of organic molecules, decomposition (acetaldehyde) Branching chain reactions and explosions (H_2-O_2 reaction). Kinetics of (one intermediate) enzymatic reaction: Michaelis–Menton treatment, evaluation of Michaelis's constant for enzyme-substrate binding by Lineweaver– Burk plot, Dixon and Eadie-Hofstae methods. Competitive and non-competitive inhibition.	15

LEARNING OUTCOME:

1. Students should be able to explain about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.
2. Students should be able to calculate the energy levels and the energy of transitions for various models and apply them to spectroscopy.
3. Students should be able to investigate the transition states and the reaction mechanism involved in the chemical reactions.

Learning Resources	
Text Books	1. Physical Chemistry, P.W. Atkins, Oxford University Press. 2. Physical Chemistry, G.W. Castellan, Narosa. Publishers, New Delhi 3. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Pub. 4. Advanced Physical Chemistry, Gurtu & Gurtu, A Pragati Edition. 5. Chemical Kinetics Methods, C. Kalidas, New Age International
Reference Books	6. Chemical Kinetics, K.J. Laidler, McGraw Hill 7. Introductory Quantum Chemistry, A.K. Chandra, Tata McGraw Hill. 8. Quantum Chemistry, I.M. Levine, Prentice Hall.

		L	T	P	C
Course Code 20CY-309	**Subject Name: Inorganic Chemistry Practical - I**	**0**	**0**	**4**	**2**
Course Category- B	**Pre-requisite –**				
	Co-requisite – 20CY-309				
	Designed by (specific department name)				

COURSE OBJECTIVE:

1. To practically apply the concepts learnt about complex-metric titrations and gravimetric methods.
2. To enable students to understand the principles behind water analysis.
3. To learn about the preparation of inorganic complex compounds.

UNIT	Course contents	Contact Hours
1	**Water Analysis** a. Determination of dissolved oxygen in a water sample. Determination of the amount of bleaching powder required to disinfect a water sample by Horrock's test. c. Determination of biochemical oxygen demand of a waste water sample d. Estimation of total, permanent and temporary hardness of water by EDTA method e. Determination of alkaline and acidity of water.	10
2	**Quantitative Analysis** a) Separation and determination of two metal ions such as Ag-Cu, Cu- Ni, Cu-Zn, Ni- Zn, Cu-Fe etc. involving volumetric and gravimetric methods.	10
3	**Preparations** i. $[Cu(NH_3)_4]^{2+}$ ii. $Mn(acac)_3$ iii. Prussian Blue/Turnbull's Blue	10

LEARNING OUTCOME:

1. Students should be able to perform complex-metric titrations and gravimetric analysis.

2. Students should be able to determine the various experimental parameters of water.

3. Students should be able to demonstrate the synthesis of inorganic complex compounds.

Learning Resources	
Text Books	**1.** Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS. **2.** Vogel's Textbook of Macro and Semi-micro Qualitative Inorganic Analysis, revised, G. Svehla, Longman. **3.** Practical Inorganic Chemistry, Marr and Rocket. **4.** Applied Chemistry by O.P. Virmani and A.K. Narula, New Age International.

		L	T	P	C
Course code-20CY-311	**Subject Name: Organic Chemistry Practical – I**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite– 20CY-311				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand safe laboratory practices by handling laboratory glassware, equipment, and chemical reagents.
2. To develop experimental skills of various separation, purification techniques and structural elucidation.
3. To understand the mono & bi-functional groups in organic compounds.
4. To impart knowledge in the synthesis of organic compounds.

UNIT	Course contents	Contact Hours
1.	Safety Practices in the Chemistry Laboratory	10
2	**Qualitative Analysis** Identification of organic compounds having mono or bi-functional groups.	10
3.	**Organic Synthesis** Two step preparations	10

LEARNING OUTCOME:

1. Students should be able to employ laboratory safety practices during handling laboratory glassware, equipment, and chemical reagents.
2. Student should be able to execute synthetic procedures by choosing suitable starting materials, functional groups, mechanism and typical reaction conditions.
3. Students should be able to perform characterization of organic molecules by physical and spectroscopic techniques.

Learning Resources	
Text Books	**1.** Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold. **2.** Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley. **3.** Advanced practical chemistry, Jagdamba, Yadav and shrivastava, Pragati Prakasan **4.** Advanced organic practical chemistry, J.N. Gurtu and R. Kappor, S. Chand **5.** Advanced practical organic chemistry, N.K. Vishnoi, Vikas Publishing House
Reference Books	**6.** Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall. **7.** Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath. **8.** Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.

		L	T	P	C
Course code-20CY-313	**Subject Name: Physical Chemistry Practical – I**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite – 20CY-313				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To motivate the students to understand the chemical kinetics.
2. To impart knowledge about the pH metric titrations.

UNIT	Course contents	Contact Hours
1	**pH metric Titrations** (i) To determine the strength of unknown strong acid against titrating with strong base. (ii) To determine the strength of unknown weak acid against titrating with strong base.	5
2	**Chemical Kinetics** (i) To study kinetics of hydrolysis of an ester in the presence of acid (ii) To determine the order for the saponification of ester (iii) Neutral salt effect - Kinetics of reaction between iodide and Persulphate - Effect of ionic strength on rate constant. (iv) Kinetics of iodination of acetone.	10
3	**Distribution Law** (i) Determination of partition coefficient of benzoic acid between benzene and water (ii) Determination of partition coefficient of iodine between carbon tetrachloride & water (iii) Determination of equilibrium constant for $I_2 + I = I_3$	10
4	Phase Equilibria i) Phase diagram of naphthalene - m-dinitrobenzene system or other system (Simple eutectic system). ii) Phase diagram of two-component system forming a compound.	5

LEARNING OUTCOME:

1. Students should be able to analyze the reaction kinetics by different methods.
2. Students should be able to predict the kinetics of various reactions.
3. Students should be able to perform the pH metric titration in analyzing the solution**.**

Learning Resources	
Text Books	**1.** Practical Chemistry, A.M. James and F.E. Pricherd, Longman. **2.** Practical Physical Chemistry, B. Levitt and Findley's, Longman. **3.** Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency. **4.** Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
Reference Books	**5.** Experiments in Physical Chemistry, Shoemaker and Garland McGraw Hill. **6.** Senior Practical Physical Chemistry, B.D. Khosla. **7.** Advanced Practical Physical Chemistry, J. B. Yadav.

Semester II

		L	T	P	C
Course Code-20CY-302	**Subject Name-Inorganic Chemistry-II (Organometallic Chemistry)**	**4**	**4**	**0**	**4**
Course Category-B	**Pre-requisite-**				
	Co-requisite-20CY-302				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the basics of Organometallic Chemistry.
2. To gain knowledge about principle of catalysis reactions.

UNIT	Course contents	Contact Hours
Unit-I	**Organometallic Chemistry** Electron count, application of 18-electron rule. Preparation and properties (Bonding modes, IR Spectra) of transition metal carbonyls and nitrosyls. **Transition Metal p–Complexes** Transition metal p–complexes with unsaturated molecules, alkenes, alkynes, allyl, & arenes and Cp (metallocene) complexes: preparation, properties and nature of bonding (MO picture) and structural features, important reactions related to nucleophile and electrophilic attack on ligands and to organic synthesis.	15
Unit-II	**Compounds of Transition Metal-Carbon Multiple Bonds** Transition metal- carbene complexes: Fischer type and Schrock type carbene complexes: synthesis, reactions and structures& bonding; Transition metal-carbyne complexes: synthesis, reactions and structural features. **Fluxional Organometallic Compounds** Fluxionality& dynamic equilibria in compounds such as acyclic alkenes, s-bonded and p–bonded cyclic alkenes, rotation of ligands on metals, ligand scrambling on metals.	15
Unit-III	**Catalysis Reactions** Oxidative addition, reductive elimination and insertion reactions. Zeigler-Natta polymerization; homogeneous catalytic hydrogenation; alkene hydrogenation- Wilkinson Catalyst; Oxidation of olefins-Wacker's process; hydroformylation of olefins the oxo process; Monsanto process. Fischer-Tropsch Reaction, The water- Gas Shift	15

	Reaction, Hydrocyanation, activation of C-H bond.	
Unit-IV	Chemistry of inorganic rings, cages and metal cluster compounds and their bonding, Chemistry of polyphosphonitriles and Borazine, polyhedral boranes, carboranes, metalloboranes and metallocarboranes, isoelectronic and isolobal analogy of metal carbonyl compounds and boranes.	15

LEARNING OUTCOME:

1. Students should be able to apply the fundamental understanding of organometallic compounds and their practical use in petroleum refining process.
2. Students should be able to design different molecules with suitable application such as drugs, and polymers by using appropriate catalyst.

Learning Resources	
Text Books	1. Principles and Application of Organo-transition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books. 2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley. 3. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International. 4. Organometallics, A. Salzer, Ch. Elschenbrioch.VCH Publications. **5.** Basic Organometallic Chemistry: Concepts, Syntheses, and Applications of Transition Metals; B. D. Gupta and A. J. Elias, University Press.
Reference Books	6. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley. 7. Inorganic Chemistry, J.E. Huheey, HarperCollins. 8. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon. 9. Inorganic chemistry, G. Wulf'sburg. 10. Introduction to ligand fields, B.N. Figgis, Wiley Eastern-IIed.

		L	T	P	C
Course Code-20CY-304	**Subject Name-Organic Chemistry-II (Organic Spectra and Reagents)**	**4**	**4**	**0**	**4**
Course Category-B	**Pre-requisite-**				
	Co-requisite-20CY-304				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To learn the basic principles of molecular spectroscopy and its applications in structure determination.
2. To understand the role of reagents in reactions.

UNIT	Course contents	Contact Hours
Unit-I	**Infrared spectroscopy** Frequency, wave length and wave number, molecular vibrations, factors influencing vibrational frequencies, the IR spectrometer, sampling techniques, characteristics frequencies of organic molecules and interpretation of spectra.	10
Unit-II	**Ultraviolet spectroscopy:** Introduction, absorption laws, measurement of the spectrum, chromophores, standard works of reference, definitions, applications of UV spectroscopy to conjugated dines, trienes, unsaturated carbonyl compounds and aromatic compounds. **Mass spectrometry** Basic Principles: instrumentation: the mass spectrometer, isotope abundances; the molecular ion, metastable ions.	15
Unit-III	**Nuclear Magnetic Resonance Spectroscopy (Proton and Carbon - NMR)** The measurement of spectra, the chemical shift: the intensity of NMR signals and integration factors affecting the chemical shifts: spin-spin coupling to ^{13}C,^{1}H-^{1}H first order coupling: some simple ^{1}H-^{1}H splitting patterns: the magnitude of ^{1}H-^{1}H coupling constants: Techniques for simplification of complex spectra: solvent effects, Lanthanide shift reagents, spin decoupling (double resonance), Fourier Transform technique, Nuclear Overhauser effect (NOE). Effect of sensitivity of ^{13}C NMR compared to ^{1}H NMR, comparison of ^{13}C NMR and ^{1}H NMR, elementary discussion on natural abundance,	20

	chemical shifts and splitting in Carbon, nitrogen, fluorine and phosphorous NMR. Simplification of ^{13}Cspectra by process of decoupling, off resonance decoupling. Introduction to 2D NMR & DEPT.	
Unit-IV	**Oxidation** Oxidations of hydrocarbons, alkenes, alcohols, aldehydes and ketones, oxidative coupling reactions. Use of $Pb(OAc)_4$, CrO_3, SeO_2, MnO_2, $KMnO_4$, OsO_4, peracids, Ozone, DDQ. **Reduction** Catalytic hydrogenation (homogeneous and heterogeneous), reduction by dissolving metals, Birch reduction, Wilkinson hydrogenation. Reduction by hydride transfer -reagents ($LiAlH_4$, $NaBH_4$, $NaBH_3CN$), Zn dust, DIBAL, 9-BBN, $LiBH_4$, BH_3, selectivity in reduction of nitroso and nitro compounds, reductive cleavage, n-Butyllithium, Grignard reagent, Dialkyl copper lithium.	15

LEARNING OUTCOME:

1. Students should be able to describe the basic principles of NMR spectroscopy such as chemical shift, coupling constant, and anisotropy.
2. Students should be able to determine molecular structure, and identification of organic compounds by analysis and interpretation of spectral data.
3. Students should be able to illustrate various palladium catalyzed coupling reactions, reducing agents, oxidizing agents, and their applications in organic synthesis.

Learning Resources	
Text Books	1. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley. 2. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley. 3. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall. 4. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw- Hill. 5. Organic Chemistry, William Kemp, John Wiley. 6. Organic Spectroscopy, Jag Mohan, Narosa Publishers, New Delhi

Reference Books	7. Introduction to spectroscopy by Donald L. pavia, Brooks cole 4th edition. 8. Reagents in Organic Synthesis, Fieser and Fieser, Wiley. 9. Reactions, Rearrangements & Reagents by Sanyal from Bharti Bhawan. 10. Reaction & Rearrangements by O P Agrawal, Goel Publication **11.** Organic reaction mechanism, V K Ahuluwalia

		L	T	P	C
Course Code-20CY-304	**Subject Name-Physical Chemistry-II (Thermodynamics and Electrochemistry)**	**4**	**4**	**0**	**4**
Course Category-B	**Pre-requisite-**				
	Co-requisite-20CY-304				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the link between macroscopic thermodynamics and microscopic quantum mechanics through different statistical methods.
2. To highlight applications of Boltzmann distribution in the fundamental concepts of electrochemistry, kinetics and macromolecules.

UNIT	Course contents	Contact Hours
Unit-I	**Thermodynamics-I** Brief resume of First and Second law of thermodynamics. Entropy changes in reversible and irreversible processes; variation of entropy with temperature, pressure and volume, entropy concept as a measure of unavailable energy and criteria for the spontaneity of reaction; free energy functions and their significance, criteria for spontaneity of a process; partial molar quantities (free energy, volume, heat concept), Gibb's-Duhem equation.	15
Unit-II	**Thermodynamics-II** Classius-Clayperon equation; law of mass action and its thermodynamic derivation. Third law of thermodynamics (Nernst heat theorem, determination of absolute entropy, unattainability of absolute zero) and its limitation. Phase diagram for two completely miscible components systems. Eutectic systems, Calculation of eutectic point, systems forming solid compounds Ax By with congruent and incongruent melting points, phase diagram and thermodynamic treatment of solid solutions.	15
Unit-III	**Electrochemistry I** Ion-Ion Interactions -The Debye-Huckel theory of ion-ion interactions: potential and excess charge density as a function of distance from the central ion, Debye-Huckel reciprocal length, ionic cloud and its contribution to the total potential, Debye-Huckel limiting law of activity coefficients and its limitations, ion-size effect on potential, ion-size parameter and the theoretical mean - activity coefficient in the case of ionic clouds with finite-sized	15

	ions. Debye-Huckel-Onsager treatment for aqueous solutions and its limitations. Debye-Huckel-Onsager theory for non-aqueous solutions, the solvent effect on the mobility at infinite dilution, equivalent conductivity vs. concentration c1/2 as a function of the solvent, effect of ion association upon conductivity (Debye-Huckel-Bjerrum equation).	
Unit-IV	**Electrochemistry II** Ion Transport in solutions – Ionic movement under the influence of an electric field , mobility of ions, ionic drift velocity and its relation with current density, Einstein relation between the absolute mobility and diffusion coefficient, the Stokes- Einstein relation , the Nernst - Einstein equation, Walden's rule, the rate-process approach to ionic migration , the rate process equation for equivalent conductivity, total driving force for ionic transport, Nernst-Planck Flux equation, ionic drift and diffusion potential , the Onsager phenomenological equations. The basic equation for the diffusion, Planck-Henderson equation for the diffusion potential.	15

LEARNING OUTCOME:

1. Students should be able to correlates the microscopic properties of systems with the macroscopic observables using the concepts statistical mechanism and thermodynamics.
2. Students should be able to apply the Boltzmann distribution law and partition functions in electrochemistry, theories of chemical kinetics and random walk models in macromolecules.

Learning Resources	
Text Books	1. Electrochemistry, S. Glasstone 2. Modern Electrochemistry vol. I and vol II J.O.M. Bockris and A.K.N. Reddy, Plenum. 3. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Pub. 4. Advanced Physical Chemistry, Gurtu & Gurtu, A Pragati Edition. 5. Physical Chemistry, P.W. Atkins, Oxford University Press.

Reference Books	6. Physical Chemistry, G.W. Castellan, Narosa. Publishers, New Delhi 7. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Pub. 8. Thermodynamics for Chemists, S. Glasstone, Affiliated East-West Press. 9. Chemical Thermodynamics, I.M. Klotz and R.M. Rosenberg, Benzamin. 10. An Introduction to Chemical Thermodynamics, R.P. Rastogi and R.R. Misra, Vikas Pub.

		L	T	P	C
Course code-20CY-310	**Subject Name: Inorganic chemistry Practical – II**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite – 20CY-310				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To motivate the students to understand the nature of cations and anions.
2. To impart knowledge about the qualitative analysis of insoluble salts.

UNIT	Course contents	Contact Hours
1	**Qualitative Analysis** a) Anion and cation analysis b) Less common metal ions- Tl, Se, Te, Mo, W, Ti, Zr, U&V c) Insolubles- Oxides (WO_3, Silica, Alumina); Sulphates (Lead Sulphate, Barium Sulphate Strontium Sulphate and Calcium Sulphate); Halides (Calcium fluoride and silver halides) (2 less common metal ions and 1 insoluble to be given)	30

LEARNING OUTCOME:

1. Students should be able to synthesize inorganic compounds, purify and characterize them.
2. Students should be able to explain the structure, properties of inorganic compounds.

Learning Resources	
Text Books	1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS. 2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, G. Svehla, Longman. 3. Practical Inorganic Chemistry, Marr and Rocket.

		L	T	P	C
Course code-20CY-312	**Subject Name: Organic chemistry Practical – II**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite – 20CY-312				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the separation methods of organic mixtures.
2. To impart knowledge in the synthesis of organic compounds.

UNIT	Course contents	Contact Hours
1	**1. Qualitative Analysis** Separation and identification of compounds of binary mixture using water/$NaHCO_3$ and HCl / NaOH and checking purity of individual component using TLC. IR spectra to be used for functional group identification.	15
2	**2. Organic synthesis** **Two Step Preparations**:	15

LEARNING OUTCOME:

1. Students should be able to demonstrate the separation and identification of compounds.
2. Students should be able to execute synthesis of organic compounds and related steps such as aqueous workup, distillation, reflux, separation, isolation, and crystallization.

Learning Resources	
Text Books	1. Experiments in Organic Chemistry" Lousis F. Fieser O.C. Heath and Company Boston, 1955. 2. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall. 3. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath. 4. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.

Reference Books	5. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold. 6. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley. 7. Advanced practical chemistry, Jagdamba, Yadav and Shrivastava, Pragati Prakasan 8. Advanced organic practical chemistry, J.N. Gurtu and R. Kappor, S. Chand **9.** Advanced practical organic chemistry, N.K. Vishnoi, Vikas Publishing House

		L	T	P	C
Course code-20CY-314	**Subject Name: Physical chemistry Practical – II**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite –20CY-314				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To motivate the students to understand the potentiometric and conductometric titrations.
2. To impart knowledge about the Thermochemistry.

UNIT	Course contents	Contact Hours
1	**Conductometric** (i) To determine the strength of strong acid by titrating against strong base. (ii) To study the precipitation reaction using conductometric titrations. (iii) To study the redox reaction using conductometric titrations.	10
2	**Potentiometry** (i) To determine the strength of strong acid by titrating against strong base. (ii) To study the precipitation reaction using potentiometric titrations. (iii) To study the redox reaction using potentiometric titrations.	10
3	**Thermochemistry** (i) Determination of heat of neutralization. (ii) To determine the strength of strong acid by titrating against strong base. (iii) To determine the strength of weak acid by titrating against strong base.	10

LEARNING OUTCOME:

1. Students should be able to execute conductometric titration of acid and base to study the details of rates of chemical reactions.
2. Students should be able to calculate the strength of acid and base.

Learning Resources	
Text Books	1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman. 2. Practical Physical Chemistry, B. Levitt and Findley's, Longman. 3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency. 4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill.
Reference Books	5. Experiments in Physical Chemistry, Shoemaker and Garland McGraw Hill. 6. Senior Practical Physical Chemistry, B.D. Khosla 7. Advanced Practical Physical Chemistry, J. B. Yadav

Semester III

		L	T	P	C
Course Code -20CY-401	**Subject Name: Structure &Mechanism in Organic Chemistry**	**4**	**4**	**0**	**4**
Course Category- B	**Pre-requisite –**				
	Co-requisite – 20CY-401				
	Designed by- Department of Chemistry				

COURSE OBJECTIVE:

1. To understand aliphatic/aromatic electrophilic &nucleophilic substitution reactions
2. To understand addition and elimination reactions in organic chemistry.
3. To gain knowledge about the addition of carbon-carbon multiple and carbon hetero bonds.
4. To learn about radicals in organic chemistry.

UNIT	Course contents	Contact Hours
Unit-I	**Aliphatic Nucleophilic Substitution** The S_N2, S_N^1, S_N^i, mixed S_N^1 and S_N2 and SET Mechanisms; neighbouring group participation by and bonds; Classical and nonclassical carbocations, phenonium ions, norbornyl system, Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident-nuleophile, regioselectivity. **Aromatic Nucleophilic Substitution** The S_N^{Ar}, S_N^1, benzyne and S_{RN}^1mechanisms. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.	15
Unit-II	**Aromatic Electrophilic Substitution** The arenium ion mechanism, orientation and reactivity. The ortho/para ratio, ipso attack, orientation in other ring systems. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction. **Elimination Reactions:** Type of elimination reactions, E1, E2 and E1cb Mechanisms. Saytzeff vs Hofmann elimination.	15
Unit-III	**Free Radical Reactions** Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of	15

	alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction.	
Unit-IV	**Addition to Carbon-Carbon Multiple Bonds** Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation. **Addition to Carbon-Hetero Multiple Bonds** Mechanism of metal hydride reduction of carbonyl compounds, acids and esters. Wittig reaction. Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.	15

LEARNING OUTCOME:

1. Students should be able to illustrate the mechanism of fundamental organic reactions.
2. Students should be able to describe the addition of carbon-carbon multiple, carbon hetero bonds and uses of radicals in organic chemistry.
3. Students should be able to explain the structural mechanism of organic reactions.

Learning Resources	
Text Books	1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley. 2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundburg, Plenum. 3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman. 4. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
Reference Books:	5. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan. 6. Organic reaction Mechanism, V K Ahluwalia and R K Prasher, Narosa Publishing House. 7. Organic reactions and their mechanisms by P S Kalsi New Age International Publishers. 8. Name Reactions and Reagents in Organic Synthesis by Bradford P. Mundy, Michael G. Ellerd and Frank G. Favaloro Jr. from Wiley. 9. Name Reactions: A Collection of Detailed Mechanisms and

	Synthetic Applications by Jie Jack Li from Springer. 10. The Art of Writing Reasonable Organic Reaction Mechanisms by Robert B. Grossman from Springer.

		L	T	P	C
Course Code -20CY-403	**Subject Name: Inorganic and Physical Spectroscopy**	**4**	**4**	**0**	**4**
Course Category- B	**Pre-requisite –**				
	Co-requisite –20CY-403				
	Designed by- Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the basic principle involved in Vibrational, Raman Spectroscopy.
2. To understand the principle involved in spin resonance and electronic spectroscopy.

UNIT	Course contents	Contact Hours
Unit-I	**Vibrational Spectroscopy** Principle of IR spectroscopy; applications of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB_2, AB_3, AB_4, AB_5 and AB_6 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, etc.) ethylenediamine and diketonate complexes, Principle and application of resonance Raman Spectroscopy particularly for the study of activesites of metalloproteins.	15
Unit-II	**Raman Spectroscopy** Quantum theory of Raman effect, Classical theory of Raman effect, Pure rotational Raman spectra, Raman activity of vibrations, vibrational Raman spectra, polarization of light and Raman effect, applications.	15
Unit-III	**Spin Resonance Spectroscopy** Spin and an applied field; the nature of spinning particles, interaction between spin and magnetic field, Larmor precession, population of energy levels. **Electronic Spectroscopy** UV-visible molecular absorption spectrometry (principle, instrumentation and applications), Jablonski diagram Frank-Condon Principle, Molecular luminescence spectroscopy (fluorescence, phosphorescence, chemi-luminescence).	15

Unit-IV	**Mossbauer Spectroscopy** The theory of Moss-Bauer spectroscopy, the chemical shift quadrupole effects, the effect of magnetic field, application of Moss-Bauer spectroscopy **Atomic Absorption Spectroscopy** Principle, instrumentation, applications, sensitivity and detection limits, interferences in AAS and their elimination.	15

LEARNING OUTCOME:

1. Students should be able to describe the basic concepts of various spectroscopic methods.
2. Students should be able to apply theoretical concepts and diffraction techniques to characterize different molecules and crystals.
3. Students should be able to distinguish between various spectroscopic transitions and interpret data for molecular characterization.

Learning Resources	
Text Books	1. Modern Spectroscopy, J.M. Hollas, John Wiley. 2. Chemical Applications of Group Theory, F.A. Cotton. 3. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill. 4. Basic Principles of Spectroscopy, G.M. Barrow, McGraw Hill. 5. Fundamentals of molecular spectroscopy, C. N. Banwell, Tata Macgraw Hill. 6. Modern Spectroscopy, J.M. Hollas, John Wiley. 7. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience. 8. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood. 9. Physical Methods in Chemistry, R.S. Drago, Saunders College.
Reference Books	10. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill. 11. Basic Principles of Spectroscopy, G.M. Barrow, McGraw Hill. 12. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley. 13. Fundamental of Instrumental Analysis, Skoog and West. 14. E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, Structural Methods in Inorganic Chemistry, 1st Edn.(1987), Blackwell Scientific Publications, Oxford, London. 15. Application of X-ray crystallography, L.S. DentGlasser,

	ELBS. 16. Fundamentals of molecular spectroscopy, C. N. Banwell, Tata Macgraw Hill. 17. Basic Concept of Analytical Chemistry, S.M. Khopkar 18. Atomic Absorption Spectroscopy, J.W. Robinson **19.** Analytical Chemistry, G.D. Christian.

		L	T	P	C
Course Code -20CY-405	**Subject Name: Bio-Inorganic & Bio-Organic Chemistry**	**4**	**4**	**0**	**4**
Course Category- B	**Pre-requisite –**				
	Co-requisite – 20CY-405				
	Designed by- Department of Chemistry				

COURSE OBJECTIVE:

1. To gain knowledge about bioinorganic molecules and their role in biology.
2. To gain knowledge about bioorganic molecules and their role in biology.

UNIT	Course contents	Contact Hours
Unit-I	**Alkali and alkaline earth metals in biological systems** Ionophores, active transport of cations across membranes, sodium-potassium pump, Calcium carriers, role of carriers in muscle contraction. **Oxygen carriers** Porphyrins, metalloporphyrins, Hemoproteins, structure and functions of hemoglobin and myoglobin, synthetic oxygen carrier model systems. **Nitrogen fixation** Biological nitrogen fixation, Nitrogenase, model for nitrogenase, metal-N_2complexes, photosynthesis and chlorophyll. **Metal transport and storage** Transferrin, Ferritin, Siderophores (without synthesis). **Porphyrins:**. Structure of chlorophyll and Haemoglobin (without synthesis).	15
Unit-II	**Metalloenzymes- I** (function and mechanism) **Zinc Enzymes** – Carboxypeptidase& Carbonic anhydrase. **Copper Enzymes** – Superoxide dismutase, blue copper-proteins. **Nickel Enzyme** - Urease **Metalloenzymes- II** (only function) **Iron Enzymes**– Catalase, peroxidase, Cytochromes (cytochrome c, cytochrome c oxidase and cytochrome P-450, non-heme iron-containing protein.	15
Unit-III	**Carbohydrates** Occurrence, classification and their biological importance. **Monosaccharides** Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation,	15

	determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation; Wohl degradation. **Disaccharides -** Structure elucidation of sucrose. **Polysaccharides -**Elementary treatment of starch, cellulose and glycogen.	
Unit-IV	**Nucleic Acids** Components of nucleic acids, Nucleosides and nucleotides. Structure of polynucleotides (DNA and RNA). Replication of DNA, transcription, translation of genetic material, genetic code, universality of the code, codon, anticodon pairing, RNA, modified nucleic acids like LNA, PNA, antisense technology, size exclusion chromatography. **Amino Acids, Peptides and Proteins** Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis. **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; **Proteins** Primary, secondary, tertiary and quaternary structures of proteins, Protein Denaturation.	15

LEARNING OUTCOME:

1. Students should be able to describe the function of alkali and alkaline earth metals in biological system.
2. Students should be able to analyze the importance of oxygen carriers in biological system.
3. Students should be able to identify the metalloenzymes, biomolecules and their importance in life.

Learning Resources

Text Books	**1.** Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentne, University Science Books. **2.** Lippard, S. J. & Berg, J. M. Principles of Bioinorganic Chemistry Univ. Science Books (1994).
Reference Books	**3.** Lippard, S. J. Progress in Inorganic Chemistry Vols. 18 and 38, Wiley-Interscience (1991). **4.** Enzo Alessio (Ed.), Bioinorganic Medicinal Chemistry, Wiley-VCH Verlag (2011). **5.** Principles of Biochemistry, A.L. Lehninger, Worth Publishers. **6.** Principles of Organic Synthesis, R. Norman and J. M. Coxon, Blakie, Academic and Professional.

		L	T	P	C
Course Code -20CY-407	**Subject Name: Photochemistry &Pericyclic Chemistry**	**4**	**4**	**0**	**4**
Course Category- B	**Pre-requisite -**				
	Co-requisite - 20CY-407				
	Designed by- Department of Chemistry				

COURSE OBJECTIVE (Specific Course objective should be mentioned below)

1. To learn about pericyclic reactions and molecular rearrangements.
2. To gain knowledge of the basic principles of photochemistry.

UNIT	Course contents	Contact Hours
Unit-I	**Photochemical Reactions** Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy. **Photochemistry of Alkenes** Intramolecular reactions of the olefinic bond- geometrical isomerism, cyclisation reactions, rearrangement of 1,4 and 1,5-dienes. **Photochemistry of Carbonyl Compounds** Intermolecular reactions of carbonyl compounds, saturated, cyclic, acyclic, and unsaturated compounds.	15
Unit-II	Intermolecular cycloaddition reactions – dimerizations and oxetane formation. **Photochemistry of Aromatic Compounds** Isomerizations, additions and substitutions. **Miscellaneous Photochemical Reactions** Photo-Fries rearrangement. Barton reaction. Singlet molecular oxygen reactions. **Free Radicals** Free radicals stability, generation and detection. Types of free radical reactions, free radicals substation at an aromatic substrate, Hunsdiecker reaction.	15
Unit-III	**Pericyclic Chemistry: Electrocyclic reactions** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions - conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems.	15

Unit-IV	**Cycloadditions** Antarafacial and suprafacial additions, 4n and 4n+2 systems, **Sigmatropic rearrangements** Suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3-and 5,5-sigmatropic rearrangements. Claisen, Sommelet Hauser and Cope rearrangements.	9

LEARNING OUTCOME:

1. Students should be able to describe the intermolecular rearrangement in olefinic and carbonyl compounds.
2. Students should be able to apply the molecular orbital symmetry and possibility of thermal and photo-chemical pericyclic reactions.

Learning Resources	
Text Books	1. Fundamental of Photochemistry, K.K. Rohtagi Mukherjee,Wiley Eastern. 2. Medicinal chemistry, 4th Edition, A. Burger, Wiley Interscience. 3. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2004). 4. Horspool, W. M. Aspects of Organic Photochemistry Academic Press (1976).
Reference Books	5. Lowry, T. H. & Richardson, K. S. Mechanism and Theory in Organic Chemistry Addison Wesley Educational Publishers, Inc. (1981). 6. March, J. Advanced Organic Chemistry John Wiley & Sons (1992). 7. Marchand, A. P. & Lehr, R. E. Pericyclic Reactions Academic Press (1977). 8. Organic Photochemistry and Pericyclic Reactions, M G Arora, Anmol Publishers, New Delhi. **9.** Pericyclic Reactions, S.M. Mukherji, Macmillan, India.

		L	T	P	C
Course code-20CY-411	**Subject Name: Chemistry Practical III**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite – 20CY-411				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the preparation and characterization methods of inorganic compounds.
2. To impart the knowledge about the Colorimetry.

UNIT	Course contents	Contact Hours
1.	Preparation of Inorganic compounds/complexes and their characterization using techniques/methods such as elemental analysis, conductance measurement, molecular weight determination, magnetic susceptibility measurements, infrared, UV, visible, etc. Handling of air and moisture sensitive compounds. a. Chromous Acetate b. $Ni(dmg)_2$ c. $[Ni(NH_3)_6]Cl$ d. $K_3[Fe(C_2O_4)_3]$	15
2.	Chromatography separation of metal ions.	5
3.	Preparation of Urea formaldehyde resin	2
4.	Preparation of Nylon 6,6.	2
5.	Preparation of Bakelite	2
6.	**Colorimetry** (i)To test the validity of Lambert Beer's Law for $KMnO_4$ and $K_2Cr_2O_7$ in H_2SO_4	4

LEARNING OUTCOME:

1. Students should be able to perform synthesize, purify and characterize inorganic compounds.
2. Students should be able to synthesize polymers.

Learning Resources	
Text Books	**1.** Synthesis and Characterization of Inorganic Compounds. W.L. Jolly, Prentice Hall. **2.** Synthesis and Physical studies of Inorganic compounds C.F. Bell, Pergamon Press. **3.** A Textbook of Quantitative Analysis. A.I. Vogel, ELBS, London.

		L	T	P	C
Course code-20CY-413	**Subject Name: Chemistry Practical IV**	**0**	**0**	**4**	**2**
Course Category-B	**Pre-requisite –**				
	Co-requisite – 20CY-413				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the multi-step synthesis and isolation of organic compounds from natural resources.
2. 2. To impart knowledge about the applications of Polarimetry.
3. To learn the determination of % composition of the mixture by viscosity method.

UNIT	Course contents	Contact Hours
1.	**Multi-step Synthesis of Organic Compounds and Isolation of Organic Compounds from Natural Sources** **(a) Multi-step synthesis** **(b) Isolation:** (i) Piperine from black pepper (ii) Lactose and casein from milk	10
2.	**Polarimetry** (i) Determination of specific rotation for optically active substance (ii) Estimation of concentration of optical active substance in the given solution	10
3.	**Viscosity** (i) To study the unknown % composition of the mixture by viscosity method.	10

LEARNING OUTCOME:

1. Students should be able to isolate and identify natural products.
2. Students should be able to estimate bio-molecules by chemical methods, and by multistep organic synthesis.
3. Students should be able to apply polarimetry to study the progress of chemical reactions.

Learning Resources	
Text Books	**Reference Books:** **1.** Practical Physical Chemistry, B. Levitt and Findley's, Longman. **2.** Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.

	3. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill. **4.** Experiments in Physical Chemistry, Shoemaker and Garland McGraw Hill. **5.** Senior Practical Physical Chemistry, B.D. Khosla
Reference Books	**6.** Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold. **7.** Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley. **8.** Advanced practical chemistry, Jagdamba, Yadav and Shrivastava, Pragati Prakasan

Semester-IV

		L	T	P	C
Course code- 20CY-402	**Subject Name: Group Theory**	**4**	**4**	**0**	**4**
Course Category- B	**Pre-requisite -**				
	Co-requisite -20CY-402				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To impart advanced knowledge based on various symmetry elements, point groups and relate their vibrational spectroscopic feature.
2. To dispense them the symmetry elements and classifying molecules on the basis of symmetry.

UNIT	Course contents	Contact Hours
Unit-I	**Symmetry and Group Theory in Chemistry** Symmetry elements & symmetry operation, group and its properties, Schonflies symbol, point groups, reduction formula, Multiplication table, application of point group assignment, representations of groups by matrices (representation for the Cn, Cnv, Cnh, Dnh etc. groups to beworked out explicity)	15
Unit-II	**Molecular Symmetry** Symmetry elements and symmetry operations in molecules, matrix representation of symmetry operation, The great orthogonality theorem (without proof) & its importance, character tables and their use in spectroscopy. Derivation of character tables (non-degenerate such as C2v, C2h), Mulliken symbols, Irreducible representation of groups. Construction of representation using vectors and atomic orbital as basis- symmetry transformation by Cartesian coordinates positioned on the atoms of a molecule.	15
Unit-III	**Molecular Vibration** The symmetry of normal vibrations, determining the symmetry types of the normal modes, cartesian coordinate and internal coordinate methods, selection rules for fundamental vibrational transitions (IR and Raman), illustrative examples.	15

Unit-IV	Construction of hybrid orbitals (BF_3, CH_4, $PC1_5$ etc.), and bonding, transformation properties of atomic orbitals, Symmetry species of hybrid orbitals, Illustrative examples from different geometries.	15

LEARNING OUTCOME:

1. Students should be able to apply the concept of symmetry in the structure and hybridization of molecule.
2. Students should be able to describe the selection rules in vibration spectroscopy and electronic spectroscopy.

Learning Resources	
Text Books	**1.** F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn. (1999), John Wiley & Sons, New York. **2.** G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 2nd Edn. (1999), Prentice Hall International Inc., London. **3.** K. Veera Reddy, Symmetry and Spectroscopy of Molecules, (1999) New Age International Pvt. Ltd., New Delhi. **4.** A. Vincent, Molecular Symmetry and Group Theory, John Wiley & Sons (1977).

		L	T	P	C
Course code-20CY-404	**Subject Name: Natural Products and Protecting Agents**	**4**	**4**	**0**	**4**
Course Category - B	**Pre-requisite -**				
	Co-requisite - 20CY-404				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To learn about heterocyclic, their structure, properties and synthesis.
2. To gain exposure to the field of total synthesis of natural products.

UNIT	Course contents	Contact Hours
Unit-I	**Terpenoids** General method of structure elucidation and synthesis of lycopene & carotene. Biosynthesis of carotenoids. **Vitamins** Structure and synthesis of vitamins A, D, E, K and Vitamin B-complex and C **Plant pigments** Structure elucidation and synthesis of Flavone, Flavonol, Chromone, Xanthone, Rutin. Biosynthesis of flavonoids: Acetate pathway and shikimic acid pathways, alkaloids.	15
Unit-II	**Enzymes** Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity. Nomenclature and classification (suitable examples of reactions). Fischer's lock & key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling, Mechanism, structure and application of enzymes like reductase, oxidase, lipase, transferase.	15
Unit-III	**Heterocyclic Compounds** General behavior, Classification & Nomenclature, Criteria of aromaticity. **Five membered Heterocycles** Synthesis and reactions of 1, 3-Azoles: Imidazole, Thiazole and Oxazole **Six membered Heterocycles with two heteroatoms** Detailed study of Pyrimidines and Purines. Structural elucidation of uric acid and caffeine.	15

Unit-IV	**Ylides** General methods of formation, General study of reactions with their mechanisms of Nitrogen (Ammonium, Immonium, Diazonium), Phosphorous and Sulphur ylides and their applications. **Protecting Group Chemistry** Role of Protective groups in organic synthesis, Protection of Hydroxy group (1, 2 and 1,3 diols), Phenols (Esters& ethers), Protection of amino group (carbamates) and Protection of carbonyl group (acetal and ketal)	15

LEARNING OUTCOME:

1. Students should be able to explain importance of various natural products including terpenes, steroids, alkaloids and polyphenols.
2. Students should be able to identify the flavour of various natural products synthesis and its characterization which is commonly found in daily life.
3. Students should be able to describe vitamins, enzyme, ylides and protection of the groups.

Learning Resources	
Text Books	**1.** Text Book of organic medicinal and Pharmaceutical chemistry, 8th Edition, R.F. Boerge, Ed. Wilson and Gisvelds, J.B. Lippincott Co. **2.** Natural Products, their chemistry and biological significance. J. Mann, R. S. Davidson, **3.** J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longmann, Essex, 1994.Medicinal Biochemistry, N. V. Bhagavan, Academic Press, Elsevier. **4.** Natural Product Synthesis II: Targets, Methods, Concepts. Topics in Current Chemistry, 24thEd. Edited by Johann Mulzer (Universität Wien). Springer: Berlin, Heidelberg, New York.2005. **5.** Natural Products from Plants 2nd ed., Cseke: National Scientific Book Agency, Delhi. **6.** Biotransformations in Organic Chemistry 5th Edition by Kurt Faber from Springer. **7.** Bio-organic Chemistry by Vinay Prabha Sharma from Pragati Edition. **8.** Chemistry of Natural Products Vol-1 & 2 by O P Aggarwal from Krishna Prakashan

Reference Books	**9.** Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. **10.** Carruthers, W. Modern Methods of Organic Synthesis Cambridge University Press (1971). **11.** Acheson, R. M. Introduction to the Chemistry of Heterocyclic Compounds John Wiley & Sons (1976). **12.** Finar, I. L. & Finar, A. L. Organic Chemistry Vol. 2, Addison-Wesley (1998). **13.** Finar, I. L. Organic Chemistry Vol. 1, Longman (1998). **14.** Protective groups in organic synthesis by Greene and Wuts from John Wiley & sons. **15.** Chemistry of natural products Vol 1 and 2 by O P Aggarwal from Goel Publication. **16.** Heterocyclic Chemistry Vol 1, 2, & 3 by Gupta, Kumar & Gupta from Springer.

		L	T	P	C
Course code- 20CY-406	**Subject Name: Chemistry in industry & environment**	**4**	**4**	**0**	**4**
Course Category - B	**Pre-requisite -**				
	Co-requisite - 20CY-406				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To understand the fundamentals of Industrial Chemistry.
2. To impart the knowledge about the advantages of Green Chemistry.
3. To acquire knowledge about asymmetric synthesis and organ-catalysis.

UNIT	Course contents	Contact Hours
Unit-I	**Industrial Chemistry** Industrial Gases and its impact in the industry and atmosphere. Petrochemicals and down stream products. Basic concepts of environmental chemistry, current trends in ecology and pollution. Chemical treatment of pollutants including CFC and PCBs. Concept of pH & buffer systems in the light of environmental aspects of chemistry. Management of carbonate, and hydrogen systems. Ozone layer depletion, global warming, acid rain and greenhouse effect, radiation hazard and noise pollution. Selected topics from current literature. Chemicals used in warfare, biological weapons.	20
Unit-II	**Green Chemistry** Principles of Green Chemistry, Concept of atom economy, Tools of Green Chemistry: Alternative feedstocks/starting materials, Reagents, Solvents, Product/target molecules, Catalysis and process analytical chemistry. Evaluation of chemical product or process for its effect on human health and environment, Evaluation of reaction types and methods to design safer chemicals. Evaluating the effects of Chemistry: Toxicity to humans, Toxicity to wildlife, Effects on local environment, Global environmental effects. Planning a green synthesis.	20
Unit-III	**Perfumery** Constitution of perfumes, odorous substances, extraction of perfumes and plants, synthesis of important synthetic chemicals used in perfumery industry esters, phenylethyl alcohol, citronellol, linalool, coumarin, vanillin, haliotropin, perfume formulation.	10

Unit-IV	**Milk industry** Chemical composition of milk, processing of milk, types of milk, manufacture of cream, butter, ghee, casein, infant milk food, malted milk food, cheese, fermented milk products. **Alcohol industry** Manufacture of absolute alcohol, beer, wine, distilled spirit, butyl alcohol, citric acid, lactic acid, and oxalic acid.	10

LEARNING OUTCOME:

1. Students should be able to identify toxicity hazards of toxic gases, safe design systems for large scale production of industrial gases, manufacturing processes handling and storage of inorganic chemicals.
2. Students should be able to explain the hazardous effects of the inorganic chemicals on human beings and vegetation, the requirement of ultra-pure metals for the semiconducting technologies.
3. Students should be able to demonstrate hands on experience in preparing milk products.

Learning Resources	
Text Books	**1.** Ahluwalia, V.K. and Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers, 2005 **2.** Anastas, P.T. and Warner, J.K. Oxford Green Chemistry - Theory and Practical, University Press, 1998 **3.** Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker, 2001 **4.** Cann, M.C. and Connely, M.E. Real-World Cases in Green Chemistry, American Chemical Society, Washington, 2000
Reference Books	**5.** Ryan, M.A. and Tinnesand, M., Introduction to Green Chemistry, American Chemical Society Washington, 2002 **6.** Lancaster, Mike, Green Chemistry an Introductory Text 2 nd Ed., RSC Publishing,. ISBN: 978- 1-84755-873-2 **7.** Dairy Technology: Vol.02: Dairy Products and Quality Assurance *Volume 2 of Dairy technology*, Shivashraya Singh Shivashraya Sing **8.** The Business of Spirits: How Savvy Marketers, Innovative Distillers, and Entrepreneurs Changed How We Drink by Noah Rothbaum.

		L	T	P	C
Course code-20CY-410	**Subject Name: Chemistry Practical –V**	**0**	**0**	**4**	**2**
Course Category - B	**Pre-requisite – No**				
	Co-requisite – Yes				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To gain knowledge about the effect on conductance as number of ions increases or decreases.
2. To get aware about the optically active compounds.

UNIT	Course contents	Contact Hours
1.	To determine saponification value of various oils.	5
2.	To estimate the iodine number.	5
3.	**Conductometry** (i) Determination of concentration of salicylic acid by (a) Salt line method (b) Double alkali method (ii) Determination of solubility and solubility product of sparingly soluble salt ($AgCl$,$PbSO_4$) (iii) Determination of degree of hydrolysis and hydrolysis constant of aniline hydrochloride in aqueous solution.	10
4	**Polarimetry** (i) Determination of percentage composition of optical substances in the given binary mixture (Glucose + Fructose or Tartaric acid) (ii) Determination of rate constant for hydrolysis/inversion of sugar	10

LEARNING OUTCOME:

1. The students should be able to describe light interaction with matter through study of optically active substances.
2. The students should be able to demonstrate the effect on conductance as number of ions increases or decreases.

Learning Resources	
Text Books	**1.** Experiments in Organic Chemistry" Lousis F. Fieser O.C. Heath and Company Boston, 1955. **2.** Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall. **3.** Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath. **4.** Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold. **5.** Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold. **6.** Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley. **7.** Organic Analytical Chemistry, Jag Mohan, Narosa Publishers, New Delhi **8.** Advanced Practical organic Chemistry N.K. Vishnoi,Vikas Publishing House.
Reference Books	**9.** Practical Chemistry, A.M. James and F.E. Pricherd, Longman. **10.** Practical Physical Chemistry, B. Levitt and Findley's, Longman. **11.** Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency. **12.** Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill. **13.** Experiments in Physical Chemistry, Shoemaker and Garland McGraw Hill. **14.** Senior Practical Physical Chemistry, B.D. Khosla **15.** Advanced Practical Physical Chemistry, J. B. Yadav.

		L	T	P	C
Course code-20CY-412	**Subject Name: Chemistry Practical –VI**	**0**	**0**	**4**	**2**
Course Category - B	**Pre-requisite –**				
	Co-requisite – 20CY-412				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To synthesis of gold nanoparticles.
2. To learn isolation technique for extraction of some important moiety from plant sources.

UNIT	Course contents	Contact Hours
1.	Bio-Diesel synthesis.	2
2.	Determination of pH of Soil	2
3.	Synthesis of Gold & Silver nanoparticles	3
4.	Greener synthesis of Gold & Silver nanoparticles using tea leaves	3
5	**Isolation** (i) Caffeine from tea leaves (ii) Cystine from human hair	10
6	**Multi-step synthesis-II**	10

LEARNING OUTCOME:

1. The students should be able to demonstrate preparation and characterization of nanoparticles.
2. The students should be able to isolate some compound from plant parts.
3. The students should be able to synthesize particular compound using multi-step approach.

Learning Resources	
Text Books	**1.** Experiments in Organic Chemistry" Lousis F. Fieser O.C. Heath and Company Boston, 1955. **2.** Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall. **3.** Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath. **4.** Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold. **5.** Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold. **6.** Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley. **7.** Organic Analytical Chemistry, Jag Mohan, Narosa Publishers, New Delhi **8.** Advanced Practical organic Chemistry N.K. Vishnoi, Vikas Publishing House. **9.** Practical Chemistry, A.M. James and F.E. Pricherd, Longman. **10.** Practical Physical Chemistry, B. Levitt and Findley's, Longman. **11.** Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.
Reference Books	**12.** Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill. **13.** Experiments in Physical Chemistry, Shoemaker and Garland McGraw Hill. **14.** Senior Practical Physical Chemistry, B.D. Khosla **15.** Advanced Practical Physical Chemistry, J. B. Yadav.

Generic Elective Course (GE-I & II)

		L	T	P	C
20CY-307/308	**Subject Name: Mathematics for Chemists**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite –**				
	Co-requisite – 20CY-307/308				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To get basic understanding of mathematics tools used in chemistry.

UNIT	Course contents	Contact Hours
Unit-I	**Vector** Examples of scalar and vectors, definitions of vectors in two, three spaces, representation and simple properties of vectors, addition and subtraction of vectors.	15
Unit-II	**Differential Calculus** Theory, rules of differentiation, powers, added and subtracted functions, constants, products, quotients, functions of a function, logarithmic differentiation, parametric functions. Algebraic simplification, differentiation of implicit functions, graphical significance of differentiation, rate of change of slope, successive differentiation. Examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution. Exact and inexact differential with their application to thermodynamic principles	20
Unit-III	**Matrices and Determinants** Definition of matrix, types of matrices, viz. row matrix, column matrix, null matrix, square matrix, diagonal matrix, addition, subtraction and multiplication by anumber, matrix multiplication.	15
Unit-IV	**Integral Calculus** Integral theory, basic rules of integration, integration by parts, partial fraction, and substitution.	10

LEARNING OUTCOME: (Specific learning outcome must be mentioned)

1. Students should be able to apply the basic mathematics concepts in chemical calculations.

Learning Resources	
Text Books	1. Mathematical Methods for Science Students, G. Stephemen, ELBS. 2. The Chemistry Mathematics Book, E. Stener, Oxford University Press. 3. Mathematics for Chemistry, Doggett and Sucliffe, Longman. 4. Mathematical Preparation for Physical Chemistry, F. Daniels, McGraw Hill. 5. Chemical Mathematics, D.M. Hirst, Longman. **6.** Applied Mathematics for Physical Chemistry, J.R. Barrante, Prentice Hall.
Reference Books	7. Basic Mathematics for Chemists, Tebbutt, Wiley. 8. Differential equation, Schaum series, Tata McGraw Hill. 9. Elements of Partial Differential Equation, I.N.Sneddom, Tata McGraw Hill. 10. Advanced Engg. Mathematics, E Kreyszig, John Wiely & sons. 11. Mathematical Techniques, Jordan &Smith, Oxford University Press.

		L	T	P	C
20CY-307/308	**Subject Name: Computer for Chemists**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite –**				
	Co-requisite– 20CY-307/308				
	Designed –Department of Chemistry				

COURSE OBJECTIVE (Specific Course objective should be mentioned below)

1. Have knowledge of most commonly used commands and library functions used in QBASIC programming.
2. Develop algorithm to solve problems and write corresponding programs in BASIC for performing calculations involved in laboratory experiments and research work.
3. Use various spreadsheet software to perform theoretical calculations and plot graphs

UNIT	Course contents	Contact Hours
Unit-I	**Computer Fundamentals** Functional components of a digital computer, concepts of hardware and software, binary, octal & hexadecimal number systems. Binary arithmetic, input/output and storage devices, Introduction to operating system and their types.	15
Unit-II	**Chem Office** Structure of molecules like proteins, DNA, RNA, Sugar, amino acids, heterocyclic compounds, chemical reactions (single step, two step & multistep) using Chemdraw. **Problem Solving:** Flowcharts, Pseudo codes, Algorithms and their application.	15
Unit-III	**Programming in C** Character set, constants and variables, reserved words, data types, expressions, scan and print statements, operators and their hierarchy, conditional, unconditional and loop control structures, One-dimensional and two-dimensional arrays, Functions.	15
Unit-IV	**Computer Application in Chemistry** Developing programs in C involving simple formulae in chemistry such as van der Waals equation, pH titration, kinetics, radio-active decay, evaluation of lattice energy and ionic radii from experimental data. Linear simultaneous equation to solve secular equations within the	15

	Huckel theory.	

LEARNING OUTCOME: (Specific learning outcome must be mentioned)

1. Students should be able to explain historical development of drugs and how chemistry and computer is connected.
2. Students should be able to apply the knowledge of computer in the field of research in chemistry.

Learning Resources	
Text Books	1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books. 2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier. 3. Steiner, E. The Chemical Maths Book Oxford University Press. 4. Yates, P. Chemical Calculations, CRC Press 5. Introduction to Computer Science, P.K. Sinha Computational Chemistry, A.C. Norris

		L	T	P	C
20CY-307/308	**Subject Name:Biology for Chemists**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite –**				
	Co-requisite –20CY-307/308				
	Designed –Department of Chemistry				

COURSE OBJECTIVE (Specific Course objective should be mentioned below)

1. To know about all the major biomolecules
2. To get to know the functions of biomolecules in our body.

UNIT	Course contents	Contact Hours
Unit-I	**Cell Structure and Metabolism** Structure of prokaryotic and eukaryotic cells, intracellular organelles and their functions, comparison of plant and animal cells. Overview of metabolic processes – catabolism and anabolism. ATP – the biological energy currency. Carbohydrate metabolism: glycolysis and Kreb's cycle.	10
Unit-II	**Carbohydrates** Conformation of monosaccharides, structure and functions of important derivatives of monosaccharides like glycosides, deoxy sugars. *N*-acetylmuramic acid, sialic acid, disaccharides and polysaccharides. Structural polysaccharides – cellulose and chitin. Storage polysaccharides – starch and glycogen. **Lipids** Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, cholesterol, bile acids, prostaglandins. Lipoproteins – composition and function. Properties of lipid aggregates-micelles, bilayers, liposomes and their possible biological functions. Lipid metabolism – oxidation of fatty acids.	20
Unit-III	**Proteins** Secondary structure of proteins, forces responsible for holding of secondary structures. A-helix, β-sheets, super secondary structure, triple helix structure of collagen. Tertiary structure of protein- folding and domain structure. Quaternary structure.	15

Unit-IV	**Nucleic Acids and Genetic Code** Structure of nucleotides, nucleosides, DNA (Watson – Crick Model) RNA structure and conformation, Replication of DNA, transcription, translation of genetic material, genetic code, universality of the code, codon, anticodon pairing, RNA, protein biosynthesis (initiation, elongation, termination and processing of the peptide chain)	15

LEARNING OUTCOME: (Specific learning outcome must be mentioned)

1. Students should be able to explain the structure and function of cells and metabolic process inside the body.
2. Students should be able to analyze the structure and function of biomolecules and genetic information.

Learning Resources	
Text Books	1. Principles of Biochemistry, A. L. Lehninger, Worth Publishers. 2. Biochemistry, L.Stryer, W.H.Freeman. 3. Biochemistry, J. David Rawn, Neil Patterson. 4. Biochemistry, Voet and Voet, John Wiley. 5. Outlines of Biochemistry, E. E.Conn and P. K. Stumpf, John Wiley.

		L	T	P	C
20CY-307/308	**Subject Name: Intellectual Property Rights (IPR)**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite -**				
	Co-requisite– 20CY-307/308				
	Designed –Department of Chemistry				

COURSE OBJECTIVE (Specific Course objective should be mentioned below)

1. To know historical development of IPR and their relevancy at the time of globalization.
2. To get to know about various organization who authorizes the trademarks and patents.
3. To let the students know the value of a patent of his innovations.

UNIT	Course contents	Contact Hours
Unit-I	**Introduction to Intellectual Property** Historical Perspective, Different Types of IP, Importance of protecting IP.	10
Unit-II	**Copyrights** Introduction, how to write &file a patent, difference between Indian and US patent, Differences from Patents. **Trade Marks** Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs. **Patents** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.	15
Unit-III	**Geographical Indications** Definition, rules for registration, prevention of illegal exploitation, importance to India. **Industrial Designs** Definition, features, International design registration. Layout design of integrated circuits Circuit Boards,	15

	Integrated Chips, Importance for electronic industry. Trade Secrets: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.	
Unit-IV	**Different International agreements** (a) Word Trade Organization (WTO): (i)General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii)General Agreement on Trade related Services (GATS) (iii)Madrid Protocol (iv)Berne Convention (v)Budapest Treaty (b) Paris Convention WIPO and TRIPS, IPR and Plant Breeders Rights, IP Infringement issue and enforcement – Role of Judiciary, cyber laws, plagiarism, Role of law enforcement agencies –Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Intellectual Property in the Indian Context – Various laws in India Licensing and technology transfer.	20

LEARNING OUTCOME:

1. Students should be able to describe the theoretical concepts of evolution of Intellectual Property Laws, and to differentiate between the different kinds of IP.
2. Students should be able to practice the existing legal framework relating to IP in India.
3. Students should be able to comprehend the value of IP and its importance in their respective domains.
4. Students should be able to recognize this course as their career in multifaceted field of intellectual property rights.

Learning Resources	
Text Books	**1.** Acharya, N.K. *Textbook on intellectual property rights*, Asia Law House (2001). **2.** Guru, M.; Rao, M.B. *Understanding Trips: Managing Knowledge in Developing Countries*, Sage Publications (2003). **3.** Ganguli, P. *Intellectual Property Rights: Unleashing the Knowledge Economy*, Tata McGraw Hill (2001).

Discipline Selective Elective Course

		L	T	P	C
20CY-408/409	**Subject Name: Polymer science & Medicinal Chemistry**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite –**				
	Co-requisite– 20CY-408/409				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To know historical development of drugs.
2. To get to know about polymers and their use in drug development.

UNIT	Course contents	Contact Hours
Unit-I	**Polymer** Terminologies-Functionality, Degree of Polymerization, Glass Transition Temperature, Classification of polymer, Molecular Weight of Polymer (Mw, Mn), Polymerization-Addition (ionic, free-radical), Co-ordination (Ziegler-Natta), Plastics- PE, Polystyrene, PVC, Teflon, PAN, PMMA, PVA, Polyesters-Polyethylene Terephthalate (PET), Epoxy Resins, Polyamide (Nylon-66, Nylon-6), Phenolic Resins (Bakelite), Amino Resins (Urea-Formaldehyde), Elastomer-Synthetic Rubber, Silicon Rubber, Molding of plastics-Compression, Injection, Extrusion.	15
Unit-II	**Inorganic polymers** Silicones, conducting polymers-Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrole, applications of conducting polymers, Ion-exchange resins and their applications. Molecular weight of polymers and its determination, effect of temperature and pressure on chain polymerization, criteria for polymer solubility; polydispersity index, Biopolymers and their applications.	15
Unit-III	**Medicinal Chemistry** Concept and definition of Pharmacophore. Pharmacodynamics and Pharmacokinetics. Drug targets: enzymes and receptors. Competitive, non-competitive and allosteric inhibitors, transition-state analogs and suicide substrates. Nucleic acids as drug targets: reversible DNA binding agents, DNA alkylating agents and DNA strand breakers. ADMET of drugs: Factors affecting Absorption,	15

	Distribution, Metabolism, Elimination and Toxicity.	
Unit-IV	History of medicinal chemistry. Drug discovery, development, design and delivery system. Receptor structure and sites. Gene therapy (antisense & anti-gene strategies) and drug resistance. General introduction to antibiotics. Neurotransmitters, class of neurotransmitters. Anti-histamines, anti-inflammatory, anti-analgesics, anti-cancer and anti-hypertensive drugs.	15

LEARNING OUTCOME:

1. Students should be able to explain about organic and inorganic polymers and properties and their applications.
2. Students should be able to identify basic concept regarding development of drugs and drugs work inside the body.

Learning Resources	
Text Books	**1.** Principles of polymerisation by George Odian, Willey, 3rd edition. **2.** Polymer characterization, physical techniques by D.campbell and J.R.White, Champman and Hall. **3.** Text book of Polymer Science, F.W. Billmeyer, Willey, 3rd edition. **4.** Plastic material by J.A. Brydson, Butterworth- Heinemann, 7th edition. **5.** Polymer: Polymer Characterization and analysis by jaquieline I Kroschwitz. Wiley Interscience. **6.** Spectrometric identification of organic compounds by R.M. Silverstein and F.X. Webster, Wiley Interscience.
Reference Books	**7.** Principles of Polymer Processing by Zehev Tadmor, Costas G. Gogos Willey,2nd edition **8.** Introduction to Thermal Analysis, by Michael E. Brown, Kluwer Academic **9.** Gringauz, A. Introduction to Medicinal Chemistry: How Drugs Act and Why? John Wiley & Sons (1997). **10.** Patrick, G. L. Introduction to Medicinal Chemistry Oxford University Press (2001). **11.** Biomedical Polymers and Polymer Therapeutics By Emo Chiellini from Springer. **12.** Polymers as Drugs, Conjugates and Gene Delivery Systems, by Ronit Satchi-Fainaro, Ruth Duncan from Springer.

		L	T	P	C
20CY-408/409	**Subject Name: Solid state & Nuclear Chemistry**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite -**				
	Co-requisite –20CY-408/409				
	Designed –Department of Chemistry				

COURSE OBJECTIVE (Specific Course objective should be mentioned below)

1. To get aware about the impact of nanotechnology on research and industries.
2. To know the latest ways by which we can determine the structures of nano-assemblies.
3. To get to know fundamentals of nuclear chemistry.

UNIT	Course contents	Contact Hours
Unit-I	**Nuclear Chemistry** Fundamentals of radioactivity and decay, preparation of radioisotopes for tracers, applications with radiotracers, radiometric titration, radioactivity measurements by gas filled and scintillation detectors. Radioactive decay, decay kinetics, parent daughter decay growth relationship, concepts of transient and secular equilibrium, alpha, beta and gamma decay, artificial radioactivity.	15
Unit-II	Introduction, Unit cell, Space lattice, Crystal, Packing in solids, Crystal structures of representative systems, Structural classification of binary (AX, AX_2, etc.) and ternary (ABX, ABX_2, ABX_3, AB_2X_4, etc.), Defects, Point defects, Line defects, Electronic properties and Band theory of solids, Electronic properties and Band theory of solids Free electron model, Metals, semiconductors and insulators, doped semiconductors, electronic structure of solids. Electrical conductivity, mobility, thermal conductivity, and specific heat of solids. Magnetic properties of solids, magnetization and susceptibility.	15
Unit-III	Characterization powder X-ray diffraction – Bragg's peak, absences, indexing of simple systems. Techniques (working knowledge) for X-ray diffraction, Electron microscopy (SEM, TEM, AFM), Thermal techniques (TG, DTA, DSC), Physical property measurement techniques (Magnetic moments-VSM /SQUID, Electrical resistivity-	15

	Two / Four probe methods and thermal conductivity, Optical band gap, XPES, XAS).	
Unit-IV	**Preparative techniques** Powder synthesis by conventional and modern chemical methods, Reactivity of solids, Decomposition mechanisms, Powder processing (sintering and diffusion processes), Tailoring of solids, Special methods for single crystal growth and thin films depositions.	15

LEARNING OUTCOME:

1. Students should be able to illustrate the basic concept of Nuclear Chemistry and their applications.
2. Students should be able to explain the internal structures and properties of solid materials.
3. Students should be able to apply X-Ray diffraction techniques in the characterization of materials.

Learning Resources	
Text Books	**1.** R. West, Solid state chemistry and its applications, John Wiley & Sons, 1989. **2.** L. Smart and E. Moore, Solid state chemistry, Chapman and Hall , 1992. **3.** K. Cheetham and P. Day, Solid state chemistry compounds, Clarendon Press, Oxford 1992. **4.** N. R. Rao and J. Gopal krishanan, New directions in solid state chemistry, Cambridge Univ. Press 1997. **5.** R. E. Newnham, Structure property relations, Springer-Verlag, 1975. P. A. Cox, Electronic structure and chemistry of solids, Oxford Univ. Press 1987. **6.** Harvey, B. C. Introduction to Nuclear Chemistry Prentice-Hall (1969). **7.** Friedlander, G. Kennedy, J. W., Marcus, E. S. & Miller, J. M. Nuclear & Radiochemistry, John Wiley & Sons (1981).
Reference Books	**8.** Polymer characterization, physical techniques by D.Campbell and J.R.White, Champman and Hall. 62 **9.** Text book of Polymer Science, F.W. Billmeyer, Willey, 3rd edition. **10.** Plastic material by J.A. Brydson, Butterworth- Heinemann, 7th edition.

	11. Polymer chemistry by C.E. Carraher, Jr. Marcel Dekker, 6th edition. **12.** A practical guide to understanding the NMR of polymers by Peter A. Mirau. **13.** H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition (1995), Wiely-Eastern Ltd.,

		L	T	P	C
20CY-409/408	**Subject Name: Green Chemistry**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite -**				
	Co-requisite– 20CY-409/408				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To get aware about the impact of research on environment.
2. To know the latest ways by which we can reduce the pollution in the environment.
3. To get knowledge about the very recent area of research i.e. Green Chemistry.

UNIT	Course contents	Contact Hours
Unit-I	**Introduction to Green Chemistry** Need for Green Chemistry, Goals of Green Chemistry, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry	10
Unit-II	Twelve principles of Green Chemistry with their explanations and special emphasis on the following with examples: Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy**.** Prevention/ minimization of hazardous/ toxic products reducing toxicity risk. Green solvents– super critical 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: use of microwaves and ultrasonic energy Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; Use of catalytic reagents in green chemistry, comparison of heterogeneous and homogeneous catalysis, bio catalysis, asymmetric catalysis and photo catalysis. Prevention of chemical accidents designing greener	20

	processes, inherent safer design, principle of ISD, greener alternative to Bhopal Gas Tragedy, subdivision of ISD, minimization, simplification, substitution, moderation and limitation. Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical process.	
Unit-III	**Examples of Green Synthesis/ Reactions and some real world cases** Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis) Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine) Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils.	20
Unit-IV	**Future Trends in Green Chemistry** Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Green chemistry in sustainable development.	10

LEARNING OUTCOME:

1. Students should be able to perform stoichiometric calculations and relate them to green chemistry metrics. Understand benefits of use of catalyst and bio catalyst, use of renewable feed stock which helps in energy efficiency and protection of the environment, renewable energy sources.

2. Students should be able to design safer chemical, products and processes that are less toxic, than current alternatives.
3. Students should be able to practice the use of green chemistry in problem solving skills, critical thinking and valuable skills to innovate and find out solution to environmental problems.
4. Students should be able to correlate chemistry to solve rather than cause environmental problems.

Learning Resources	
Text Books	**1.** Ahluwalia, V.K. and Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers, 2005 **2.** Anastas, P.T. and Warner, J.K. Oxford Green Chemistry - Theory and Practical, University Press, 1998 **3.** Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker, 2001 **4.** Cann, M.C. and Connely, M.E. Real-World Cases in Green Chemistry, American Chemical Society, Washington, 2000 **5.** Ryan, M.A. and Tinnes and, M., Introduction to Green Chemistry, American Chemical Society Washington, 2002
Reference Books	**6.** Lancaster, Mike, Green Chemistry an Introductory Text 2 nd Ed., RSC Publishing,. ISBN: 978- 1-84755-873-2 **7.** Reagents in Organic Synthesis, Fieser and Fieser, Wiley. **8.** Reactions, Rearrangements & Reagents by Sanyal from Bharti Bhawan. **9.** Reaction & Rearrangements by O P Agrawal, Goel Publication.

		L	T	P	C
20CY-409/408	**Subject Name: Analytical Chemistry**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite -**				
	Co-requisite– 20CY-409/408				
	Designed –Department of Chemistry				

COURSE OBJECTIVE:

1. To get knowledge of all the basic instrumentations for characterization of the structures of molecules like drugs, dyes and natural products.
2. To learn about distinguishing between molecules.

UNIT	Course contents	Contact Hours
Unit-I	**Qualitative and quantitative aspects of analysis** Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.	10
Unit-II	**Optical methods of analysis** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. *UV-Visible Spectrometry:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; *Basic principles of quantitative analysis*: estimation of metal ions from aqueous solution, geometrical isomers, keto-enoltautomers. *Flame Atomic Absorption and Emission Spectrometry*: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.	20
Unit-III	**Thermal methods of analysis** Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. **Electroanalytical methods** Classification of electro analytical methods, basic	15

	principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.	
Unit-IV	**Separation techniques** Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.	15

LEARNING OUTCOME:

1. Students should be able to execute experiment with accuracy and precision.
2. Students should be able to develop methods of analysis for different samples independently.
3. Students should be able to apply basic principle of instrument like Flame Photometer, UV-vis spectrophotometer in the analysis of water sample.
4. Students should be able to practice separation of analytes by chromatography.

Learning Resources	
Text Book	**1.** Vogel, Arthur I: A Text book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman. **2.** Willard, Hobart H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988. Christian, Gary D; Analytical Chemistry, 6 th Ed. John Wiley & Sons, New York, 2004.Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001. **3.** Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009. **4.** Skoog, D.A., Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore, 1998.

Reference Books	**5.** Mikes, O. and Chalmers, R.A. Ed. Laboratory Hand Book of Chromatographic and Allied Methods, Elles Horwood Ltd. London. **6.** Christian, G. D., Analytical Chemistry, 6th Ed., John Wiley & Sons, Inc. (2004). **7.** Skoog, D. A., West, D. M., Holler, R. J & Nieman, T. A. Principles of Instrumental Analysis Saunders Golden Sunburst Series (1997). **8.** Willard, H. H., Merritt, L. L., Dean, J. A. & Settle, F. A. (Eds.) Instrumental Methods of Analysis - 7th Ed., Wadsworth Publishing (1988) ISBN 0534081428 **9.** Khopkar, S. M. Concepts in Analytical Chemistry Halsted (1984). **10.** Dilts, R.V. Analytical Chemistry – Methods of separation Van Nostrand 1974.

		L	T	P	C
20CY-409/408	**Subject Name: Pharmaceutical Chemistry**	**4**	**4**	**0**	**4**
Course Category-P	**Pre-requisite -**				
	Co-requisite – 20CY-409/408				
	Designed –Department of Chemistry				

COURSE OBJECTIVE (Specific Course objective should be mentioned below)

1. To enable students to understand the principles of drug action.
2. To learn about synthesis of drugs.
3. To learn basic classification of drugs.

UNIT	Course contents	Contact Hours
Unit-I	**General mode of action, Medicinal Uses and Synthesis of Important Drugs in the Following Categories.** **Antineoplastic Agents** Metastasis, classification, mode of action of alkylating agents (synthesis of mephalan, thiotepa, busulfan, lomustine) and antimetabolites (synthesis of methotrexate, 5-fluorouracil, 6-mercaptopurine), hormone based therapies, plant products, radio-therapeutic agents. **Antiviral agents** RNA and DNA viruses, an introduction to AIDS, how HIV infects the system, mode of action of nucleoside reverse transcriptase inhibitors- AZT, DDI, DDC, D4T & 3TC and HIV-protease inhibitors-Ritonavir (RTV). **Antimalarials** **Structure and Functions of:** Cinchona alkaloids, 4-aminoquinolines, 8-aminoquinolines, Mefloquine, 9-aminoacridines. Synthesis of Metaquine, chloroquine, primaquine	15
Unit-II	**Antibiotics** Historical backgrounds of antibiotic discovery β-Lactam antibiotics: Penicillin, Cepholosporins, β-Lactamase inhibitors, Monobactams Aminoglycosides: Streptomycin, Neomycin, Kanamycin Tetracyclines:Tetracycline, Oxytetracycline, Chlortetracycline, Minocycline, Doxycycline Macrolides- mode of action, Erythromycin, erythromycin, azithromycin;	15

	Recent advancement in the field of antibiotics.	
Unit-III	**Prostaglandins** General Introduction about Prostaglandins, Non-Steroidal anti-inflammatory agents: Classification, mode of action, COX-2 inhibitors, salol principle. Synthesis of aspirin, phenbutazone, mefanamic acid, indomethacin, piroxicam, diclofenac, Naproxen **Antipyretic-Analgesics** Opoid antagonists and agonists-codeine and heroin, synthesis of meperidine, methadone, dextropropoxyphen	15
Unit-IV	**Antihypertensive agents** Classification, Hypertension, Renin-Angiotensin system, mode of action, Calcium channel blockers, ACE inhibitors and β-blockers, centrally acting adrenergic drugs, peripherally acting sympatholytics- Synthesis of atenolol, clonidine, methyldopa, guanabenz, diltiazem, captopril, enalapril. **Contraceptive agents** Ovulation inhibitors and related hormonal contraceptives-norethindrone, norethynodrel, estradiol and mestranol.	15

LEARNING OUTCOME: (Specific learning outcome must be mentioned)

1. Students should be able to illustrate retro-synthesis approach in relation to drug design and drug discovery.
2. Students should be able to describe synthetic pathways of major drug classes.
3. Students should be able to discuss the fermentation process and production of ethanol, citric acids, antibiotics and some classes of vitamins.

Learning Resources	
Text Book	**1.** Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, Ed. Robert F. Dorge. **2.** Burger's Medicinal Chemistry and Drug Discovery Vol-I Ed. M.E. Wolf, John Wiley. **3.** Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill. **4.** Organic Chemistry Vol.-2 I.L. Finar, ELBS.