M.Sc. Chemistry Syllabus

(with effect from 2021)

DEPARTMENT OF CHEMISTRY

The Gandhigram Rural Institute –Deemed to be University
Gandhigram – 624 302

Tamil Nadu

TEMPLATE FOR PG PROGRAMME

S.NO	CATEGORY	NO. OF CREDITS
1.	Gandhi in Everyday Life	02
2.	Communication and Soft skills	02 08
3.	Village Placement Programme	02
4.	Human Value and Professional Ethics	02
S.	Core Courses i)Dissertation ii) Modular Course: (2 Courses) iii) Electives: a) Discipline Centric (1course) b) Generic (1 course) iv)Major Course : Minimum 60credits Maximum 72 credits (Theory and Practical) iv) Internship/Field visit (if required)	06 04 16 03 03 60- 72
	Total	84-96

Semester-wise credits distribution for M. Sc. Chemistry-2021

Template for PG Programme

Course code	Title of the Course	Credits	Hours		Max Marks		
			Theory	Practical	CFA	ESE	Total
FIRST SEMESTER							
21CHEP0101	Inorganic Chemistry -I	4	4	-	40	60	100
21CHEP0102	Organic Chemistry – I	4	4	-	40	60	100
21CHEP0103	Physical Chemistry – I	4	4	-	40	60	100
21CHEP0104	Analytical Chemistry	4	4	-	40	60	100
21CHEP0105	Organic Chemistry Practical-I	2	-	5	60	40	100
21CHEP0106	Physical Chemistry Practical–I	2	-	5	60	40	100
21GTPP0001	Gandhi in Everyday Life	2	2	-	50	-	50#
Total		**22**	**18**	**10**			
SECOND SEMESTER							
21CHEP0207	Inorganic Chemistry – II	4	4	-	40	60	100
21CHEP0208	Organic Chemistry – II	4	4	-	40	60	100
21CHEP0209	Physical Chemistry – II	4	4	-	40	60	100
21CHEP0210	Inorganic Chemistry Practical-I	2	-	5	60	40	100
21CHEP0211	Physical Chemistry Practical– II	2	-	5	60	40	100
21CHEP02GX	Generic Elective	3	3	-	40	60	100
21CHEP2VSX	Value Added Course	2	2	-			
21ENGP00C1	Communication and Soft Skills	2	2	-	50	-	50#
Total		**23**	**19**	**10**			

*** Course code will be given by the respective department offering the course**

Not included for CGPA calculation

THIRD SEMESTER							
21CHEP0312	Inorganic Chemistry -III	3	3	-	40	60	100
21CHEP0313	Organic Chemistry – III	3	3	-	40	60	100
21CHEP0314	Physical Chemistry – III	3	3	-	40	60	100
21CHEP0315	Inorganic Chemistry Practical-II	2	-	5	60	40	100
21CHEP0316	Organic Chemistry Practical-II	2	-	5	60	40	100
21CHEP0317	Mini-Project	1	-	-	50	-	50
21CHEP03DX	Discipline Centric Elective	3	3	-	40	60	100
21CHEP03MX	Modular Course	2	2	-	50	-	50
21EXNP03V1	VPP	2	-	-	50	-	50#
Total		**21**	**14**	**10**			
FOURTH SEMESTER							
21CHEP0418	Inorganic Chemistry –IV	4	4	-	40	60	100
21CHEP0419	Organic Chemistry – IV	4	4	-	40	60	100
21CHEP0420	Physical Chemistry – IV	4	4	-	40	60	100
21CHEP04MX	Modular Course	2	2	-	50	-	50
21CHEP0421	Dissertation	6	-	12	75	75+ 50	200
21CHEP4VS4	Human Values and Professional Ethics	2	2	-	-	--	-
Total		**22**	**16**	**12**			
Grand Total		**88**	**67**	**42**			

*** Course code will be given by the respective department offering the course**

 # Not included for CGPA calculation

LIST OF DISCIPLINE CENTRIC ELECTIVE COURSES OFFERED (4 credits)

1. 21CHEP03D1 - Polymer Chemistry
2. 21CHEP03D2 - Physical Organic Chemistry
3. 21CHEP03D3 - Medicinal Chemistry
4. 21CHEP03D4 - Environmental Chemistry
5. 21CHEP03D5 - Supramolecular Chemistry
6. 21CHEP03D6 - Advanced Methods in Organic synthesis

LIST OF GENERIC ELECTIVE COURSES OFFERED (4 credits)

1. 21CHEP02G1 - Elements of Biochemistry
2. 21CHEP02G2 - Instrumental Methods of Chemical Analysis
3. 21CHEP02G3 - Pollution and its Control Measures

LIST OF MODULAR COURSES OFFERED (2 credits)

1. 21CHEP03M1 - Advanced Functional Materials
2. 21CHEP03M2 - Nanotechnology and its Applications
3. 21CHEP04M1 - Molecular Electronics and Organic Photovoltaics
4. 21CHEP04M2 - Water Quality Monitoring, Management and Treatment
5. 21CHEP04M3 - Green Methods in Chemistry

LIST OF VALUE ADDED COURSES OFFERED (2 credits)

1. 21CHEP02VS1 - Design thinking innovation and product development
2.21CHEP02VS2 - Computation tools in chemistry
3. 21CHEP02VS3 - Materials for biological applications
4. 21CHEP04VS4 - Human Values and Professional Ethics

Semester	I	Course Code	21CHEP0101
Course Title	Inorganic Chemistry -I		
No. of Credits	4	No. of contact hours per week	4 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: Analyse K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to develop an understanding of both structure and chemical bonding of inorganic compounds and the basic concepts of acids and bases.		

UNIT	Content	No. of Hours
I	**Bonding Models I** Ionic bond - Lattice energy and determination - Born-Lande equation with derivation - Importance of Born Mayer equation and Kapustinskii equation - Application of Born-Haber type calculations - Size effects - Ionic radii - Factors affecting ionic radii - Lewis structure - VB theory. Molecular orbital theory - Symmetry and overlap - Molecular orbitals diagram of diatomic and triatomic molecules - Formal charge.	12
II	**Bonding Models II** Hybridization - Molecular orbital equivalent of hybridization-Delocalization - Resonance - Molecular orbital equivalent of resonance. Fajan's rule - Results of polarization - Covalent bonding in ionic solids - polarizing power - polarizability- Charge distribution in molecules - Dipole moment - Determination and applications.	12
III	**Solid State Chemistry I** Cells and description of crystal structure-symmetry-seven crystal systems - Close packing of spheres - Packing efficiency - Hexagonal close packed (HCP) and cubic close packed structures (CCP) - Coordination number - Relative density of packing in simple cubic, CCP, HCP and BCC - Tetrahedral and octahedral holes - Limiting radius ratio rule. Radius ratio for trigonal, tetrahedral, octahedral and cubic sites - Radius ratio and shape of ionic crystals - Structures of cesium chloride, sodium chloride, zinc blende, fluorite, rutile and calcite.	12

IV	**Solid State Chemistry II** Perovskite structure of spinels - Stoichiometric defects - Schottky and Frenkel defects - Non-stoichiometric defects - Metal excess and metal deficiency defects - Extended defects - Line and plane defects. Band theory - Semiconductors - Intrinsic and extrinsic type - Fermi level- Flow of current in semiconductors - Hopping mechanism - Band structure - p and n type semiconductors - p-n junction - Superconductivity - 1,2,3-superconductor – Photovoltaic effect. Solid state reactions - Classification - Thermal decomposition reactions - Reaction between two solids - Improving reactivity of solids.	12
V	**Acid-Base Concept** Acid-Base concept- Solvent system concept - Bronsted Lowry- Lux-Flood - Lewis concept and Usanovich concept - Classification of Lewis acids - Lewis acid-base reactions - nonaqueous solvent and acid base strength- super acids - Solvolysis and formation of coordination compounds. Hard and Soft Acids and Bases (HSAB) – Theory of Hard and Soft Acids and Bases – Applications of HSAB theory -Strength of oxyacids - Pauling's rule - Acidity of cations in aqueous solution- solvation and acid base strength- Factors affecting relative strength acids and bases- substituents-steric effect-resonance effect.	12
References	1. Inorganic Chemistry, D.F. Shriver, P.W. Atkins and CH.Langford, ELBS, Oxford University Press, 6th Edn.,2015. 2. Inorganic Chemistry, J.E. Huheey, E.A. Keither and R.L. Keiter, Harper Collins College Publisher, New York, 4th Edn.,1993. 3. Modern Inorganic Chemistry, W.E. Jolly, McGraw Hill International Edition, New York,1994. 4. Theoretical Principles of Inorganic Chemistry, G. S. Manku, Tata McGraw Hill Publishing Company Ltd., New Delhi,1994. 5. Concepts and Models of Inorganic Chemistry, B. Douglas, D.H.Me Daniel and J.J. Alexander, John Wiley and Sons, New Delhi,2001. 6. Solid State Chemistry, D.K. Chakrabarthy, New Age International Publishers, NewDelhi, 2005.	
Course Outcomes	➢ Describe atomic structure, orbital concepts, chemical bonding and their properties in inorganic molecules ➢ Explain the periodic properties of elements ➢ Predict the stability of reactive intermediates and explain the reaction mechanism	
References		
	E-Resources	

	1. 2.
Course Outcomes	After completion of the course the student will be able to CO1: Predict the chemistry and structure of ionic compounds besides explaining the theories involved. CO2 : Assess the types of hybridization involved in ionic solids CO3: Identify the types of crystal structure exist in ionic solids CO4: Explain the types of defects in metals, band theory and solid state reactions CO5: Outline the basic concept of acids-bases and theories involved in it

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (3)	✓ (2)	✓ (2)
CO2	✓ (3)	✓ (2)	✓ (3)	✓ (2)	✓ (2)
CO3	✓ (3)	✓ (2)	✓ (2)	✓ (3)	✓ (1)
CO4	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (1
CO5	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (1)

Semester	I	Course Code	21CHEP0102
Course Title	Organic Chemistry - I		
No. of Credits	4	No. of contact hours per week	4 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill, Employability		
Cognitive Levels addressed by the course	K-1: K-2: K-3: Apply K-4: Analyse K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to develop an understanding of reactivity organic compounds, reaction mechanisms and synthetic utility of some important organic reagents and characterization of organic compounds by NMR. The course also will give an understanding of the chemistry of some selected		

	heterocyclic compounds.	
UNIT	Content	No. of Hours
I	**Methods of Determination of Reaction Mechanisms and Aromaticity** Thermodynamic and Kinetic Requirements of Reactions: Thermodynamic and kinetic control – methods of determination of reaction mechanisms – product analysis – determination of the presence of intermediate, isolation, detection, trapping – cross over experiments – isotopic labeling – isotopic effect – stereo chemical evidence – kinetic evidence.Kinetic Methods of Determination of Reaction Mechanisms: Hammett equation – significance of substitution and reaction constant – Hammond postulates – Linear free energy relationship – limitations and deviations – Taft equation. Aromaticity: Conditions for aromaticity, Aromatic systems with 2,6,10 electrons, alternent and non-alternent hydrocarbons, systems of more than 10 electrons annulenes- aromaticity of azulenes, ferrocene and sydnones - Aromatic, nonaromatic, antiaromatic systems- concept of homoaromaticity	12
II	**Reaction Mechanism** Reaction Mechanism: Nucleophilic substitution at saturated carbon atom- S_N1 and S_N2 reactions- mechanism and evidences- effect of structure- solvent- stereochemistry- S_Ni, S_N1', S_N2', S_N1cA and S_N2cA mechanism-Neighbouring group participation- Non classical carbocations. S_NAr mechanisms. Elimination Reactions: E1, E2 and E1cB – evidences – effect of structure, solvent and base – Hoffmann and Saytzeff rules – stereochemistry of E1 reaction- Pyrolytic elimination – cis elimination – elimination vs substitution.	12
III	**Organic Reagents-I** Study of synthetic applications of the following reagents - LDA, LiHMDS, ^{n}BuLi –ortholithiation, DMAP, DDQ, $Pd(PPh_3)_4$, Simmon-Smith Reagent, Gilman's Reagent, Woodword & Prevost Hydroxylation and Peterson's Synthesis	8
IV	**Chemistry of Heterocyclics** **Oxygen Heterocyclics**: Classification, color reactions of various classes of flavonoids– chemistry and synthesis of	16

	flavones (luteolin), isoflavones (daidzein), flavonols (kaempferol) and anthocyanidins (cyanidin). **Nitrogen Heterocyclics**: Synthesis and reactivity of indole, pyrazole, imidazole, pyrimidines – uracil, cytosine, purines – adenine, guanine and caffeine.	
V	**NMR Spectroscopy** NMR Spectroscopy: ^{1}H–NMR spectroscopy: Chemical shifts – spin-spin coupling – coupling constant – analysis of first order spectra – spin-spin splitting – shielding, deshielding, anisotropic effect – AX, AX_3, A_2X_3, AMX, ABX, AB_2, A_2B_2 systems – Karplus equation – factors influencing the coupling constant J – influence of stereochemical factors on chemical shift of protons – Protons-deuterium exchange phenomenon, chemical spin decoupling of rapidly exchangeable protons (-OH, -SH, -COOH, -NH, -NH_2) – non I order spectra – simplification of complex spectra – double resonance – shift reagents – NOE and its applications. ^{13}C-NMR spectroscopy: low natural abundance – ^{1}H decoupling – off resonance study-effect of alkyl and halogen substitution, hybridization effects. Basic principles of 2D NMR spectroscopy – NOESY, COSY.	12
References	1. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Structure and Mechanisms, Part A, 5th Edition, Springer, 2007. 2. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th edition, Pearson Education. 3. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 1st edition, Oxford University Press, 2001. 4. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis-An Introduction, W. H. Freeman and Company, 2006. 5. W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, 4th edition Cambridge University Press. 6. H. O. House, Modern Synthetic Reactions, Benjamin-Cummings Publishing Co. 2nd edition, 1972. 7. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric identification of organic compounds, 7th edition, John Wiley, 2005. 8. Organic Spectroscopy, W. Kemp, 3rd edition, Macmillan, 2011. 9. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw Hill, 6th edition 2007. 10. D. L. Pavia and G. M. Lampman Spectroscopy 4th Edition, Brooks Cole, 2012. 5. H. Gunther, NMR	

	Spectroscopy Wiley-VCH, 2013. 11. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th edition, New age international, 2007. 12. I.L. Finar, Organic Chemistry, Vol.2 ELBS, 5th edition, 1974 and Pearson India, 5th edition, 2011.
Course Outcomes	1. Assess the thermodynamic and kinetic controlled products and methods of determination of reaction mechanisms. 2. Describe and formulate the mechanism of various nucleophilic substitution reactions and elimination reactions. 3. Elucidate the structure of organic compounds using NMR spectroscopy. 4. Assess the mechanism and synthetic uses of selected reagents. 5. Describe the chemistry of Nitrogen and oxygen heterocycles.
References	
	E-Resources 1. 2.
Course Outcomes	After successful completion of the course, the student will be able to CO1: Assess the thermodynamic and kinetic requirements of the reaction and predict the reaction mechanism CO2: Explain the reaction mechanism of nucleophilic substitution reactions and elimination reactions CO3: Choose and employ the right reagents for carrying out organic reactions CO4: Explain the identity of flavonoids and synthesize them CO5: Synthesize various heterocyclic compounds CO6: Characterise organic compounds using NMR techniques

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (1)	✓ (3)	✓ (1)
CO2	✓ (3)	✓ (3)	✓ (1)	✓ (3)	✓ (2)
CO3	✓ (2)	✓ (3)	✓ (2)	✓ (3)	✓ (1)
CO4	✓ (1)	✓ (1)	✓ (1)	✓ (3)	✓ (1)
CO5	✓ (1)	✓ (1)	✓ (1)	✓ (3)	✓ (1)
CO6	✓ (2)	✓ (3)	✓ (1)	✓ (3)	✓ (2)

Semester	I	Course Code	21CHEP0103
Course Title	PHYSICAL CHEMISTRY I		
No.of Credits	4	No. of contact hours per week	4 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The content of this course is designed to give the knowledge of different laws of thermodynamics and various concepts of electrochemistry. The course also emphasizes the importance of rechargeable batteries and fuel cells.		

UNIT	Content	No. of Hours
I	**Thermodynamics and Non-ideal Systems** Chemical potential, Gibbs-Duhem equation, variation of chemical potential with temperature and pressure. Fugacity-definition. Determination of fugacity of gases by graphical method and from equations of state. Variation of fugacity with temperature and pressure. Fugacity and the standard state for non-ideal gases. Fugacity and mixtures of non-ideal gases, chemical equilibrium involving non-ideal gases. Physical significance of fugacity. Definition of activity and activity coefficient-variation of activity with pressure and temperature-determination of activity and activity coefficient of non-electrolytes. Lewis Randal rule-Duhem-Margules equation.	12
II	**Third Law of Thermodynamics and Chemical Equilibrium** Third law of thermodynamics, Nernst heat theorem, unattainability of absolute zero, calculation of absolute entropies based on third law of thermodynamics, residual entropy and its application. Virial equation of state. Chemical equilibrium-Thermodynamic derivation of equilibrium constant for equilibrium involving ideal and real gases-Temperature dependence of the equilibrium constant-Vant-Hoff equation.	12
III	**Non-equilibrium Thermodynamics and Phase Rule** Basic concept of non-equilibrium thermodynamics-postulates and methodologies-linear laws-Entropy of irreversible processes-Clausius in equality-entropy production (heat flow, chemical reactions, electrochemical reactions) and entropy production in open systems- phenomenological equations-Onsager reciprocity relation. **Phase equilibrium:** Gibbs phase rule-derivation-	12

	applications to three component systems-Graphical representation -Systems of three liquids-systems consisting of two salts and water.	
IV	**Electrochemistry I** Electrical double layer: Structure of electrical interface, parallel plate condenser model, Gouy-Chapmann diffused charge model, Stern model, limitations of these models. Semiconductor interfaces, Theory of double layer at semiconductor-electrolyte solution interfaces, Lippman equation. Electrocatalysis-influence of various parameters. Butler-Volmer equation-low field and high field approximations-Tafel equation. Thermodynamics and kinetics of electrochemical metal deposition and dissolution process (corrosion), mechanism, corrosion current, Evan's diagram, Protection and prevention of corrosion.	12
V	**Electrochemistry II** Ionic strength-Debye Huckel theory-Debye-Huckel limiting law-relaxation effect-electrophoretic effect-Debye-Huckel-Onsager (DHO) conductance equation - validity of DHO equation-deviations from the DHO equation. Conductivity at high frequency and at high field strength. Debye – Falkenhagen effect and Wien effect Lead-acid batteries-Cadmium-Nickel oxide batteries-charging and discharging reactions-Lithium rechargeable batteries. Fuel cells-classification-chemistry of fuel cells- detailed description. Supercapacitors-types of supercapacitors.	12
References	1. Electrochemical Methods Fundamentals and Applications, Allen J. Bard and Larry R. Faulkner 2nd Edn., John Wiley and Sons,2004. 2. Fuel Cells-Principles and Applications, B.Viswanathan, M.Aulice Scibioh, Universities Press, Hyderabad, India,2006. 3. Modern Electrochemistry, John M. Bockris and Amulya K.N. Reddy, Vol. I & II, 2nd Edn., Springer, New Delhi,2000. 4. Physical Chemistry, P.W. Atkins, Oxford University Press,1998. 5. Thermodynamics for students of Chemistry, Kuriakose and Rajaram, Shoban Lal Nagin Chand, 1986.D.R. Crow, Principles and Applications	
Course Outcomes	At the end of the course, students will be able to: ➢ Assess the basic concepts in reversible and irreversible thermodynamics. ➢ Describe the basic theories at the electrolyte-electrode interfaces. ➢ Outline the electrochemical principles involved in corrosion and energy storage devices. ➢ Identify the different types of fuel cells and discuss their merits and demerits.	
References	Text Books (with chapter number & page number, wherever needed):	

	1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course , the student will be able to CO1: Assess the basic concepts in reversible and irreversible thermodynamics CO2: Analyze the phase diagrams for two and three component systems CO3: Compare the different theories proposed at electrode-electrolyte interface CO4: Outline the electrochemical principles involved in corrosion and energy storage devices. CO5: Identify the different types of fuel cells and discuss their merits and demerits.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓ (1)	✓ (2)		
CO2	✓ (3)			✓ (2)	
CO3	✓ (1)	✓ (1)	✓ (1)	✓ (1)	
CO4	✓ (2)		✓ (2)	✓ (1)	✓ (1)
CO5	✓ (3)		✓ (2)	✓ (2)	✓ (1)

Semester	I	Course Code	21CHEP0104
Course Title	ANALYTICAL CHEMISTRY-I		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: Analyse K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to give the students an in-depth account of various modern analytical techniques like spectrophotometry, XRD, radiometry, thermal and electroanalytical techniques with a view to understand the		

	principles, instrumentation and applications. The course also gives account of statistical treatment of data and chromatographic techniques.	
UNIT	Content	No. of Hours
I	**Statistical Treatment of Data, Separation Techniques and Intellectual Property Rights** Errors-classification-minimization of errors-accuracy, precision, standard deviation, coefficient of variance, Q-test and t-test, significant figures, rules for rejection of analytical data. Chromatography-principles, instrumentation and applications of GC and HPLC, Ion- exchange techniques. Solvent extraction - factors favoring solvent extraction-Batch and Continuous process. Introduction to Intellectual Property: Historical Perspective, Different Types of IP, Importance of protecting IP. Patent: Introduction, patenting process and requirements of patenting.	12
II	**Spectrophotometry and XRD** Atomic absorption spectrophotometry (AAS)-principle, instrumentation and applications, types of interferences. Flame emission spectroscopy (FES)-theory, instrumentation and applications-Difference between AAS and FES. Inductively coupled plasma atomic emission spectroscopy (ICEP-AES) and inductively coupled plasma mass spectrometry (ICP-MS)-principle and applications. XRD-principle- single crystal-powder crystal methods and application.	12
III	**Radiochemical and Thermal Methods of Analysis** Isotopic dilution methods-direct and inverse-neutron activation analysis. Absolute and comparator methods-Radiometric titrations-types – applications. Principles, instrumentations and applications of thermogravimetry, Differential thermal analysis and differential scanning calorimetry-thermograms of calcium oxalate monohydrate and copper sulphate pentahydrate.	12
IV	**Electroanalytical Techniques I** Polarography-principle-polarographic maxima-Ilkovic equation-Half-wave potential- applications. Cyclic voltammetry-principle-interpretation of cyclic voltammogram for a reversible	12

	couple- -simple analytical applications-chemically modified electrodes-modification of electrodes by different methods-ultramicroelectrodes in voltammetry-Differential pulse voltammetry.	
V	**Electroanalytical Techniques II** Basic principles of coulometry-coulometry at controlled potential-coulometry at constant current-coulometric titrations-advantages and applications-theory of chronopotentiometry and chronoamperometry. Anodic stripping voltammetry-principle and applications-ion selective electrodes-characteristics-different types-principle and applications.	12
References	1. Instrumental methods of analysis, H,W. Willard, L.I. Merrit, J.J.A. Dean and F.A. Settle, CBS publishers,1983. 2. Principles of Instrumental methods of analysis, Skoog and West, Saunders College Publications, 1992. 3. Instrumental methods of chemical analysis, B.K. Sharma, Goel publishing House, 19th Edn.,2000. 4. Electrochemical Methods, Fundamentals and Applications, A.J. Bard and L.R. Faulkner, John Wiley & Sons, 2nd Edn.,2001. 5. Intellectual property rights in the WTO and developing countries, J.Watal,Oxford University Press, Oxford,2001. 6. Principles of Instrumental methods of analysis, D. A. Skoog, F. J. Holler, F. J. and R. Stanley, Boston: Cenage Learning, 7thEdn, 1992.	
Course Outcomes	At the end of the course, students will be able to: ➢ Analyze the accuracy and precision of the statistical data. ➢ Summarize the principles and applications of AAS and XRD. ➢ Describe the different thermal methods and radiometric titrations. ➢ Apply different electroanalytical techniques for the detection of metal ions at trace level.	
References		
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	After successful completion of course the student will be able to CO1: Analyze the accuracy and precision of the statistical data. CO2: Describe the separation techniques for purification of compounds.	

	CO3: Explain the intellectual property rights and process of patenting. CO4: Summarize the principles and applications of AAS and XRD. CO5: Describe the different thermal methods of analysis and radiometric titrations. CO6: Apply different electroanalytical techniques for the detection of metal ions and toxic compounds at trace level.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (2)	✓ (2)	✓ (1)
CO2	✓ (3)	✓ (2)	✓ (2)	✓ (2)	✓ (2)
CO3	✓ (2)	✓ (3)	✓ (2)	✓ (2)	✓ (1)
CO4	✓ (3)	✓ (2)	✓ (2)	✓ (2)	✓ (1)
CO5	✓ (3)	✓ (2)	✓ (1)	✓ (2)	✓ (1)
CO6	✓ (3)	✓ (2)	✓ (1)	✓ (1)	✓ (2)

Semester	I	Course Code	21CHEP0105
Course Title	ORGANIC CHEMISTRY PRACTICAL-I		
No. of Credits	2	No. of contact hours per week	5 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The practical course is designed to acquire skill in separation and qualitative analysis.		

Content	No. of Hours
1. Different laboratory techniques-Melting point, Distillation-at atmospheric pressure-at reduced pressure, TLC, Column Chromatography, Crystallization, Sublimation, Preparation of dry solvents.	60
2. Separation and qualitative analysis of two component mixtures of organic compounds- Characterization of derivatives and identification of the components.	
3. Single stage preparation of organic compounds using classical organic reactions such as nitration, bromination, acetylation, condensation and oxidation by green approach.	

4. Extraction of caffeine from tea leaves, piperine from pepper, lachanoric acid from lichens and casein from milk	
References	1. Vogel's Text Book of Practical Organic Chemistry, Furniss, S. B.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R. 5Th Ed.; Longman Scientific & technical, England, 1989. 2. Laboratory Manual of Organic Chemistry, Dey and Sitaraman, Allied Publishers, 1992.
Course Outcomes	At the end of the practical course, students will be able to: 1. Adopt different laboratory techniques for crystallization and sublimation. 2. Formulate strategies for the separation and qualitative analysis of two and three component mixtures of organic compounds. 3. Plan for the preparation of desired organic compounds, extraction and purification of organic compounds.
References	Text Books (with chapter number & page number, wherever needed): 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to .CO1: Adopt different laboratory technique for crystallization and sublimation , Plan for the preparation of desired organic compounds and purification of organic compounds CO2: Formulate strategies for the separation and qualitative analysis of two and three component mixture of organic compounds

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓(3)	✓ (3)	✓ (3)	✓ (3)
CO2	✓ (1)	✓(3)	✓ (3)	✓ (3)	✓ (3)

Semester	I	Course Code	21CHEP0106
Course Title	PHYSICAL CHEMISTRY PRACTICAL-I		
No. of Credits	2	No. of contact hours per week	5
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The practical course is designed to set-up different electrochemical cells and to carry out different applications of potentiometric, pH metric, conductometric titrations and to verify the theories by conductometry method.		

	Content	No. of Hours
	1. Setting up of various cells and measurement of their values, Examples: Zn /0.1M $ZnSO_4$/ KCl / Hg_2Cl_2 / Hg / Ag / AgCI / 0.l M KCl / Hg_2Cl_2/ Hg/ Hg_2Cl_2/ KCl/ 0.1 M $CuSO_4$/Cu.	
	2. Determination of redox potentials and equivalence points from potentiometric titration. 3. Determination of the solubility and solubility product of silver chloride in water potentiometrically. 4. Potentiometric titration of a mixed solution of KCl and KI against$AgNO_3$. 5. Determination of dissociation constant of a weak acid by pH metric titration. 6. pH metric titration of mixture of weak acid and strong acid against strong base. 7. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. 8. Experimental verification of Debye-Huckel-Onsager equation. 9. Conductometric titration of a mixture or a weak acid and strong acid against a strong base. 10. Determination of neutralization enthalpy of HCl and CH_3COOH by NaOH. 11. Determination of solution enthalpy by thermometric method. Oxalic acid-water, $K_2Cr_2O_7$- water and naphthalene -toluene.	60

References	1. Experimental Physical Chemistry, G. Peter Mathews, Oxford Science Publications, 1985. 2. Experimental Physical Chemistry Ed, by E. Danielset al., International student edition, McGraw Hill

	KogakushaLtd.,1970. 3. Senior Practical Physical Chemistry, D. D. Khosala, A. Khosala, V. C. Gard, R. Chand & Co., New Delhi,1975. 4. Practical Physical Chemistry, B. Viswanathan and P. S. Raghavan, Viva Books Pvt. Ltd., New Delhi, 2008.
Course Outcomes	At the end of the practical course, students will be able to: 1. Set-up of different electrochemical cells Analyze the dissociation constant and solubility product by conductometry and potentiometry respectively. 2. Identify the thermodynamics of simple systems. 3. Assess and adopt the conductometric methods to verify the theories
References	
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to .CO1: Setup different electrochemical cells, Analyze the dissociation constant and solubility product by conductometry , potentiometry respectively CO2: Assess and adopt the conductometric methods to verify the theories and identify the thermodynamics of simple systems.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓(3)	✓ (1)	✓ (1)	✓ (2)
CO2	✓ (2)	✓(1)	✓ (2)	✓ (3)	✓ (2)

Semester	II	Course Code	**21CHEP0207**
Course Title	INORGANIC CHEMISTRY II		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: Remember K-2: Understand K-3: Apply K-4: Analyse K-5: Evaluate K-6:		
Course Objectives (Maximum.5)	The objective of the course is to impart knowledge in bonding, reaction mechanisms and electronic spectra of coordination compounds.		
UNIT	Content		No. of Hours
I	**Coordination Chemistry (Bonding)** Crystal field theory (CFT) –Postulates of CFT - Crystal field splitting in octahedral, tetrahedral and		12

	square planar complexes - Crystal field stabilization energy and its applications in stereochemistry, stability of oxidation states, trends in heats of hydration & lattice energy and colour& magnetic properties- Weak and strong fields - Pairing energy - Factors affecting the magnitude of crystal field splitting-Jahn-Teller theorem – Limitations of CFT.	
II	**Coordination Chemistry (Bonding & Properties)** Molecular orbital (MO) theory for octahedral, tetrahedral and square planar complexes- Types of pi-bonds-Effect of pi-bonding on crystal field splitting – Experimental evidences for pi -bonding. Symbiosis - Chelate effect – Magnetic properties – Dia, para, ferro and antiferro magnetisms - Curie's law – Spin isomerism. Stability constants of complexes and their determination methods (Ion exchange, electrochemical, polarographic, spectrophotometric and method of continuous variation methods)-Factors influencing stabilityconstants of metal complexes with respect to the nature of metal ion and ligand.	12
III	**Coordination Chemistry (Reaction Mechanism I)** Substitution reactions: General mechanism - Schemes of octahedral, tetrahedral and square planar complexes – Dissociative (D) – Associative (A) - Interchange (I) and dissociation types - Linear free energy relationships- Acid and base hydrolysis reactions-Substitution reaction without M-L bond breaking. Racemisation and isomerisation: Twist mechanisms for isomerisation – Intra molecular mechanisms forracemisation.	12
IV	**Coordination Chemistry (Reaction Mechanism II)** Labile and inert complexes-VBT and CFT-Trans-effect - Theories of trans-effect, pi-bonding theory and polarization theory- Application of trans effect-cis effect. Redox reactions: complementary and non-complementary reactions-Inner sphere mechanism - The role of bridging ligand - Outer sphere mechanism - The limiting rate law - Theoretical treatment of electron transfer - Simple applications to bio-inorganic chemistry.	12
V	**Coordination Chemistry (Electronic spectra of complexes)** Quantum numbers of multi -electron atoms - Russell-Sanders coupling - L-S coupling and micro states – Ground state terms for d^1 – d^{10} ions- Derivation of terms for p^2 , p^3, d^1 and d^2 configurations - Hund's rules in the determination of lowest energy states - Selection rules for electronic transitions – Charge transfer transitions - Ligand to metal charge transfer and metal to ligand charge transfer. Splitting of free ion terms in octahedral field - correlation diagram - Orgel diagrams for $[M(H_2O)_6]^{n+}$ (M = d^1 to d^9 ions) d^1 to d^9 ions and Tanabe-Sugano diagrams for d^2 and d^3 ions.	12
References		
Course Outcomes	At the end of the course, students will be able to:	

	➢ Explain crystal field theory, crystal field splitting in complexes , its limitations, and constructing MO diagrams of complexes. ➢ Categorize the mechanical aspects of inorganic complexes. ➢ Describe trans effect, theories of trans effect and redox reactions. ➢ Analyze and interpret the electronic spectra of coordination complexes.
References	
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After completion of course the student will be able to CO1: Apply crystal field theory to explain properties of complexes and constructing MO diagram of complexes CO2: Discuss the mechanistic aspects of various substitution reactions of inorganic complexes CO3: Explain trans effect, theories of trans effect and redox reactions CO4: Analyze and interpret the electronic spectra of coordination complexes

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)		✓ (1)	✓ (2)	
CO2	✓ (3)		✓ (1)		✓ (1)
CO3	✓ (2)	✓ (1)	✓ (1)	✓ (1)	
CO4	✓ (2)	✓ (1)		✓ (3)	

Semester	II	Course Code	21CHEP0208
Course Title	ORGANIC CHEMISTRY-II		
No.of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to understand various organic reactions and reagents, to have advanced knowledge in UV-vis		

	and IR spectroscopy, to know the chemistry of organic molecules based on conformational analysis, to understand the chemistry of terpenoids.	
UNIT	Content	No. of Hours
I	**UV-vis and IR Spectroscopy** UV-vis spectroscopy: Different regions of electromagnetic spectrum – Electronic energy levels, electronic transitions and selection rules– Factors affecting the position of UV-vis bands – effect of structure and solvents- Woodward- Fischer rules for calculating absorption maxima of conjugated dienes,-α,β-unsaturated carbonyl compounds – Disubstituted benzene derivatives. **IR Spectroscopy:** Molecular vibrations- factors influencing vibrational frequencies– group frequency concept- hydrogen bonding- effect of inductive and mesomeric effects on carbonyl stretching frequency- effect of ring strain on carbonyl stretching frequency- applications of IR spectroscopy to organic compounds	12
II	**Organic Reactions (oxidation, reduction and name reactions)** Oxidation: Mechanism and applications of reaction involving oxidation with CrO_3, OsO_4, SeO_2, $NaIO_4$, mCPBA and Swern oxidation. Reduction: Mechanism and applications of reaction involving reduction with $NaBH_4$, $LiAlH_4$, DIBAL-H, Bu_3SnH. Name Reactions: Robinson annulations, Suzuki Coupling, Wittig reaction, Stark enamine synthesis and Shapiro reaction.	12
III	**Molecular Rearrangements** Molecular Rearrangements: 1,2- shifts in carbocations –Curtius, Lossen, Demjanov, Bayer Villiger, Favorski, Benzidine, Nebar, Hoffmann- Lofller- Freytag rearrangement	12
IV	**Conformational Analysis** **Conformational Analysis of acyclic system:** conformation of halogenoalkanes, conformation of diastereomers- conformational effects on reactivity- acyclic systems only- addition reactions- elimination reactions. **Conformational Analysis of Cyclic Compounds:** cyclohexane- chair, skew boat- boat conformations- mono and disubstituted cyclohexane-stable conformer- physical properties-Von Auwers Skitta rule- conformations of cis and trans decalins. Conformations of perhydroanthracene and perhydrophenanthracene - conformationally rigid and mobile diastereomer, quantitative correlation between conformation and reactivity, Winstein- Eliel equation, Curtin-Hammett principle, Steric assisted and steric hindered reactions	12

V	**Terpenoids** Terpenoids: Biogenesis- isoprene rules - classification of terpenoids - structure and synthesis of zingiberene, α-cadinene, α-pinene, camphor and abietic acid.	12
References	1. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric identification of organic compounds, 7th edition, John Wiley, 2005. 2. Organic Spectroscopy, W. Kemp, 3rd edition, Macmillan, 2011. 3. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw Hill, 6th edition 2007. 4. D. L. Pavia and G. M. Lampman Spectroscopy 4th Edition, Brooks Cole, 2012. 5. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th edition, New age international, 2007. 6. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part B, Fifth Edition, 2007 7. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 1st edition, Oxford University Press, 2001. 8. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis-An Introduction, W. H. Freeman and Company, 2006. 9. W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, 4th edition Cambridge University Press. 10. H. O. House, Modern Synthetic Reactions, Benjamin-Cummings Publishing Co. 2nd edition, 1972. 11. A. J. Kirby, Stereoelectronic Effects, Oxford University Press, 1996. 12. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds Wiley Student Edition, 2008. 13. I.L. Finar, Organic Chemistry, Vol.2 ELBS, 5th edition, 1974 and Pearson India, 5th edition, 2011.	
Course Outcomes	At the end of the course, students will be able to: ➢ To Know the knowledge of UV-vis and IR NMR spectra ➢ Describe and formulate the mechanism of oxidation, reduction, rearrangements reactions and some selected name reactions. ➢ Predict and analyze the conformations of acyclic and cyclic organic compounds. ➢ Elucidate the structure and propose synthesis of selected terpenoids.	
References	Text Books (with chapter number & page number, wherever needed): 1. 2.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	After successful completion of the course, the student will be able to	

	CO1: To characterize the compounds using UV-Vis and IR spectroscopy CO2: To choose and employ the right reagent for bringing out the oxidation and reduction reaction CO3: To explain the mechanism of rearrangement reactions CO4: To predict the stereochemistry of the acyclic and cyclic molecules and explain their reactivity and stability CO5: To elucidate the structure of terpenoids compounds

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (1)
CO2	✓ (2)	✓ (3)	✓ (2)	✓ (3)	✓ (1)
CO3	✓ (2)	✓ (1)	✓ (2)	✓ (3)	✓ (1)
CO4	✓ (1)	✓ (2)	✓ (1)	✓ (2)	✓ (2)
CO5	✓ (2)	✓ (1)	✓ (2)	✓ (2)	✓ (1)

Semester	II	Course Code	21CHEP0209
Course Title	PHYSICAL CHEMISTRY- II		
No.of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to have an introductory idea of quantum chemistry and basic concepts of group theory and its applications.		
UNIT	Content		No. of Hours
I	**Quantum Chemistry I** Success of quantum theory and failure of classical mechanics-experimental foundation of quantum mechanics-black body radiation-photoelectric effect. Compton effect and atomic spectra. Formulation of quantum mechanics-the wave nature of sub-atomic particles-wave particle dualism-Heisenberg's uncertainty principle-Schordinger wave equation. Concept of operators-sums and products of operators-commutator-linear and non-linear operators-Hermitian and Hamiltonian operators- Deriving operators for energy and angular momentum from known operators-Eigen values and Eigen functions-postulates of quantum mechanics- physical interpretation of wave function-		12

	orthogonality and normalization theorems.	
II	**Quantum Chemistry II** Applications of wave mechanics-Schrodinger wave equation to free particle-particle in a one- dimensional box-particle in a three dimensional cubic and rectangular box-degeneracy. One- dimensional harmonic oscillator-classical treatment of simple linear harmonic oscillator and its limitations-quantum mechanical treatment-complete solutions for linear harmonic oscillator-Hermite polynomial and orthogonality-Normalized solution and energy values. Rigid rotator-rigid rotator as a model fora rotating diatomic molecule-solutions.	12
III	**Quantum Chemistry III** Solving of Schrodinger equation for the H-atom (or H-like species)-energy levels- quantum numbers radial factors and angular parts. Atomic orbitals and their shapes-electron spin and Pauli's exclusion principle.-approximation methods-need for approximation methods- Perturbation theory (I order only)-application to H-like atoms-Variation method-Application to helium atom-Molecular orbital theory-LCAO-MO treatment-MO theory of simple heterodiatomic molecules like HF, LiH, CO and NO.	12
IV	**Basics of Group Theory** Definition of a mathematical group and its properties – symmetry elements - symmetry operations – classes of symmetry operations - group multiplication table - cyclic groups-subgroups - classes –classification of molecular point groups. Matrix representations of symmetry operations-representation of groups-reducible and irreducible representations. The Great Orthogonality theorem and its consequences-character tables – construction of character tables for C_{2v} and C_{3v} point groups.	12
V	**Applications of Group Theory in Chemistry** Group theory and quantum mechanics – direct product - wave function as bases for irreducible representation - Symmetry Adapted Linear Combinations (SALC)-projection operators and their use to construct SALC-Huckel approximation-concept of hybridization-hybridization in methane - secular determinant – symmetry factoring of secular equations- MOs for butadiene, benzene - spectral transition probabilities -electronic spectra-selection rule-electronic transition in formaldehyde-vibrational spectra – normal modes of vibration - selection rules – mutual exclusion principle-IR and Raman activity of fundamentals in H_2O, N_2F_2 and CH_4.	12
References	1. Introductory Quantum Chemistry, A.K. Chandra, Tata McGraw-Hill Publishing Company, 4th edn.,1994. 2. Quantum Chemistry, R.K. Prasad, Wiley Eastern, New Delhi,1992. 3. Introductory Quantum Mechanics, Y.R. Waghmare, Eurasia Publishing House, New Delhi, 1989. 4. Fundamentals of Quantum Chemistry, Anandaraman, MacMillan, India,2001 5. F.A. Cotton, Chemical Applications of Group Theory, 3rdedn., Wiley-Interscience Publications, 2006. 6. A. Salahuddin Kunju and G. Krishnan group theory and its applicationsin Chemistry, Eatern Economy Edition, 2nd edition,	

	PHI Learning Publishers, 2015. 7. P.K. Bhattacharya, Group Theory and Its Chemical Applications, Himalayan Publishing House, 1986. 8. V. Ramakrishnan and M.S. Gopinathan, Group Theory in Chemistry, Vishal Publications, 1998.
Course Outcomes	At the end of the course, students will be able to: ➢ Describe the basic concepts and applications of quantum chemistry. ➢ Categorize the operators and Eigen functions. ➢ Formulate the approximation methods to construct molecular orbitals. ➢ Identify the point groups of molecules and apply the concepts of group theory to predict the spectroscopic properties.
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to CO1: Compile the basic concepts and applications of quantum chemistry. CO2: Explain the different operators and eigen functions. CO3: Apply wave mechanics to solve Schrodinger wave equation for different systems. CO4: Use the approximation methods to construct molecular orbitals. CO5: Identify the point groups of molecules and apply the concepts of group theory to predict the spectroscopic properties.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (2)		
CO2	✓ (2)			✓ (2)	
CO3		✓ (2)			
CO4	✓ (2)		✓ (2)	✓ (2)	✓ (2)
CO5	✓ (2)		✓ (2)	✓ (2)	✓ (2)

Semester	II	Course Code	21CHEP0210
Course Title	INORGANIC CHEMISTRY PRACTICAL-I		
No. of Credits	2	No. of contact hours per week	5
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course	Basic Skill		

(may be more than one)		
Cognitive Levels addressed by the course	K-1: K-2: K-3: K-4: Analyse K-5: K-6:	
Course Objectives (Maximum.5)	The practical course is designed to develop skills in identification of elements by inorganic qualitative analysis and also preparation of some inorganic complexes.	
	Content	No. of Hours
1. Analysis of mixtures containing two common and two less common cations. Ions of the common metals: Pb, Cu, Mn, Cr, Al, Ni, Co, Ba, Sr, Ca, Mg Ions of less common metals: W, Se, Te, Mo, Ce, Th, Zr, Ti, V, U, Li.		60
2. Inorganic Preparations a. Hexamminecobalt(III) Chloride b. Tatraamminecopper(II) Sulphate c. Hexaaminechromium(III)Nitrate d. Hexaureachromium(III)Chloride e. Tris(ethylendiamine)nickel(II) Chloride f. Tris(ethylenediamine)chromium(III)Chloride g. Potassiumtris(oxalato)ferrate(III) h. Potassiumtris(oxalato)chromate(III) i. Potassiumtris(oxalato)cuprate(II) j. Potassiumhexathiocyanatochromate(III) k. Potassiumtetrathiocyanatodiamminechromate(III) l. Hexathiourealead(II)nitrate		
References	Inorganic Semi-Micro Qualitative Analysis, V.V. Ramanujam, The National Publishing House, Chennai,1990.	
Course Outcomes	At the end of the practical course, students will be able to: ➢ Analyze most common and less common ions by using semi-micro inorganic qualitative methods. ➢ Formulate suitable methods for the preparation of desired inorganic complexes	
References	Text Books (with chapter number & page number, wherever needed): 1 2.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	After successful completion of the course, the student will be able to .CO1: Analyze most common and less common ions by using semi-micro inorganic qualitative analysis. CO2: Formulate suitable methods for the preparation of desired inorganic complexes	

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓(3)	✓ (2)	✓ (3)	✓ (2)
CO2	✓ (1)	✓(3)	✓ (3)	✓ (2)	✓ (3)

Semester	II	Course Code	**21CHEP0211**
Course Title	PHYSICAL CHEMISTRY PRACTICAL – II		
No.of Credits	2	No. of contact hours per week	5
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The practical course is designed to study the chemical kinetics of different reactions, the adsorption behavior of compounds on solid surfaces, and to determine the concentration of analytes in a mixture by colorimetry.		

Content	No. of Hours
1. Determination of the temperature coefficient and energy of activation of hydrolysis of ethyl acetate. 2. Determination of the rate constant and order of reaction for the reaction between potassium persulphate and potassium iodide. 3. Study of the kinetics of the reactions between iodine and acetone. 4. To determine the rate constant of iodine clock reaction. 5. To study the adsorption of acetic acid/oxalic acid in activated charcoal and verify the Freundlich and Langmuir adsorption isotherms. 6. To determine the relative viscosities of various liquids using Ostwald viscometer. 7. To determine the molecular weight of a polymer by viscosity method. 8. Estimation of concentration of a mixture by colorimetric method. 9. Construction of a phase diagram for a three-component system (toluene/ chloroform-water-acetic acid) 10. To test the validity of Lambert Beer's law for $KMnO_4$ and $K_2Cr_2O_7$ in H_2SO_4. 11. Determine the composition of the binary mixture containing $KMnO_4$ and $K_2Cr_2O_7$	60

References	
	1. Experimental Physical Chemistry, G. Peter Mathews, Oxford Science Publications,1985. 2. Experimental Physical Chemistry Ed, by E. Daniels, International Student Edn., McGraw Hill,1970. 3. Senior Practical Physical Chemistry, D.D. Khosala, A. Khosala, V.C. Gard, R.Chand & Co., New Delhi, 1975. 4. Practical Physical Chemistry B. Viswanathan

	and P.S. Raghavan, Viva Books Pvt. Ltd., New Delhi, 2008.
Course Outcomes	At the end of the practical course, students will be able to: ➢ *Determine the kinetics of the reactions.* ➢ *Analyze physisorption and chemisorptions mechanisms.* ➢ *Identify the concentration and composition of liquids by refractometry.* ➢ *Predict the concentration of two analytes in a mixture*.
References	Text Books (with chapter number & page number, wherever needed):
	Reference Books:
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to . CO1: *Determine the kinetics of the reactions , analyze physisorption and chemisorptions mechanisms* CO2: Identify the concentration and composition of liquids by refractometry and predict the concentration of two analytes in a mixture.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (1)	✓(2)	✓ (3)	✓ (1)	✓ (2)
CO2	✓ (1)	✓(1)	✓ (3)	✓ (3)	✓ (2)

Semester	II	Course Code	21CHEP02G2
Course Title	INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Discipline Centric Elective		
Scope of the Course (may be more than one)	Advanced Skill, Employability		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: Apply K-4: Analyse K-5: K-6:		

Course Objectives (Maximum.5)	The objective of the course is to develop knowledge in instrumental methods of chemical analysis, to learn the importance of statistical treatment of analytical data, and to understand basic principles, instrumentation and simple applications of spectrochemical,electrochemical, polarimetric, thermal and radiometric techniques.	
UNIT	Content	No. of Hours
I	**Statistical Treatment of Analytical Data** Accuracy and precision-significant figures-errors-types of errors-absolute and relative error-mean and relative mean deviations-standard deviation-student's t-test.	12
II	**Theoretical Principles** Basic idea of law of mass action-Le Chatelier principle-the dissociation theory-common ion effect-solubility product -pH scale and buffer solution and buffer action. Problems based on pH and buffer.	12
III	**Separation Techniques** extraction-ion-exchange method-principle of chromatography-column, thin layer and gas chromatography-principle methodology and simple applications-elementary idea about HPLC.	12
IV	**Spectrochemical Techniques** Absorption of light - Beer's law - UV-Visible and IR spectrophotometry - principle, instrumentation and simple applications. Nuclear Magnetic Resonance (NMR) Spectroscopy: Introduction to NMR spectroscopy, including principles of chemical shifts, spin-spin coupling, and applications in structural elucidation of organic compounds.	12
V	**Electroanalytical, Polarimetry, Thermal and Radiometric Techniques** Basic principles and instrumentation of potentiometry, polarimetry and thermogravimetry-simple applications. Principle, instrumentation and simple applications of radiometric titrations-activation. Voltammetry and Polarography: Overview of voltammetric methods, including cyclic voltammetry and polarography, and their applications in analyzing electroactive species.	12
References	1. Instrumental methods of chemical analysis, G. Chatwal and S. Anand, Himalaya Publishing House, New Delhi,1999. 2. Instrumental Methods of Analysis, H.W. Willard, L.I. Merrit, J.A. Dean and P.A. Settle, CBS Publishers, 7thEdn., 1996.	
Course Outcomes	At the end of the course, the students will be able to: ➢ Analyze the experimental data and present it systematically. ➢ Describe and adopt suitable separation techniques. ➢ Identify and assess quantitatively using various spectrochemical and electrochemical methodsandwhattechniqueshouldbeusedfortheanalysistosolveapartic ularproblem. ➢ Predict the physical and chemical principles upon which the analytical measurement is based.	
References		
	Reference Books: 1. 2	
	E-Resources	

	1. 2.
Course Outcomes	After successful completion of course the student will be able to ➢ *Analyze the experimental data and present it systematically.* ➢ *Describe and adopt suitable separation techniques.* ➢ *Identify and assess quantitatively using various spectrochemical and electrochemical methodsandwhattechniqueshouldbeusedfortheanalysistosolveapartic ularproblem.* ➢ *Predict the physical and chemical principles upon which the analytical measurement is based.*

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (1)	✓ (1)	✓ (1)
CO2	✓ (3)	✓ (2)	✓ (1)	✓ (2)	✓ (1)
CO3	✓ (3)	✓ (3)	✓ (3)	✓ (1)	✓ (3)
CO4	✓ (3)	✓ (3)	✓ (2)	✓ (3)	✓ (2)
CO5	✓ (2)	✓ (1)	✓ (3)	✓ (2)	✓ (2)

Semester	II	Course Code	21CHEP02G3
Course Title	POLLUTION AND ITS CONTROL MEASURES		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Generic Elective		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to provide comprehensive introduction to pollution of air, water, noise and nuclear pollution. In addition, the course also deals with pollutants and their impact on global environment and human health.		
UNIT	Content		No. of Hours
I	**Air Pollution** Major regions of the atmosphere – composition of air – specific air pollutants and their effects – CO, CO_2, SO_2, SO_3, NO and NO_2 – ozone depletion – acid rain – photochemical smog.		12
II	**Water pollution** Criteria for potable water – major water pollutants – organic, inorganic, heavy metals –		12

	(As, Cr, Fe, Pb, Cd, Hg) oil spills – sources – effects.	
III	**Soil and Pesticide Pollution** Sources, effects of various oil pollutants – pesticides – classification. Toxicity of DDT, BHC, malathion, parathion, carbamates. Alternative sources for pesticides.	12
IV	**Noise and Nuclear Pollution** Noise pollution – sources and effects – nuclear pollution – genetic and somatic effects nuclear disasters and major accidents.	12
V	**Regulatory Framework** Introduction to national and international regulations and policies aimed at controlling pollution. Overview of agencies and organizations involved in pollution control.	12
References	1. Environmental Chemistry, A. K. De, 5th edn., New Age International Publisher,2005. 2. Environmental Chemistry, B. K. Sharma, 11th edn., Krishna Prakashan Media Limited, 2007.	
Course Outcomes	At the end of the course, students will be able to: ➢ *Identify pollutants and their effect on environment and human health.* ➢ *Describe the analytical methods to determine water and air quality parameters.* ➢ *Propose water treatment methods for domestic and industrial purposes*	
References		
	Reference Books: 1. 2	
	E-Resources 1. 2.	
Course Outcomes	After successful completion of course the student will be able to CO1: Identify pollutants and their effect on environment and human health CO2: Describe the analytical methods to determine water and air quality parameters. CO3: Propose water treatment methods for domestic and industrial purposes.	

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (1)		✓ (2)
CO2	✓ (2)			✓ (2)	
CO3		✓ (3)			
CO4	✓ (3)		✓ (2)	✓ (3)	✓ (2)
CO5	✓ (2)	✓ (2)	✓ (3)	✓ (2)	✓ (2)

ester	III	Course Code	**21CHEP0312**
Course Title	INORGANIC CHEMISTRY- III		
No. of Credits	3	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to develop an understanding of the chemistry of metal complexes, metallocenes and various reactions of organometallics, to appreciate the use of organometallic reagents in organic synthesis, to understand the chemistry of chains, rings, cages and clusters of inorganic compounds and to gain knowledge on functions of metal ions, mechanistic aspects of photosynthesis, oxygen transport in biological systems.		
UNIT	Content		No. of Hours
I	**Organometallic Chemistry I** 18 electron rule - Concept of hapticity - Preparation, structure and bonding in polynuclear carbonyl, nitrosyl and dinitrogen complexes-Applications of IR spectra in the study of structure of metal-carbonyls. Preparation, structure and bonding in metal carbenes, carbynes, alkenes, alkynes and allyl complexes.		12
II	**Organometallic Chemistry II** Metallocenes – classification – Preparation, properties and bonding in ferrocene – MO theory - cycloheptatriene and tropylium complexes. Reactions of organometallics: Mechanism of substitution reactions in carbonyl complexes – Mechanism of oxidative addition and reductive elimination and		12

	insertion and elimination reactions – C-H activation.	
III	**Organometallic Chemistry III** Organometallic reagents in organic synthesis: Synthetic importance of iron pentacabonyl and organo palladium complexes. Homogeneous catalysis: Alkene hydrogenation, hydroformylation, Monsanto acetic acid process, Wacker process - photodehydrogenation catalyst- polymerization by Ziegler-Natta catalyst – Isomerization of alkenes.	12
IV	**Chains, Rings, Cages and Clusters Chains** Isopoly anions and heteropoly anions of V, Cr, Mo and W. Rings: Synthesis and reactions of borazines, S-N ring compounds, phosphazenes, phosphazene polymers - Structures and bonding of phosphazene. Cages: Phosphorus, phosphorus trioxide and pentoxide - Borane carborane and metallocarboranes compounds - Higher boron hydride classification and electron counting. Clusters: Dinuclear, tetranuclear and hexanuclear cluster - Polyatomic zintl anions and cations –Chevral phases.	12
V	**Bioinorganic Chemistry** Metal ions in biology- Mechanism of ion transport across membranes-Sodium and potassium pump, Photosynthesis – PS- I, PS-II, Porphyrins, Metalloenzymes-Carbonicanhydrase, superoxide dismutase, xanthine oxidase, nitrogenaseand Carboxypeptidase, Oxygen transport and storage- Hemoglobin, myoglobin, hemerythrin, and hemocyanin. Metal ion transport and storage: Ferritin, Transferrin, Siderophores and metallothionein.Electron Transfer-Cytochromes, Iron-Sulfur Proteins and Copper Proteins -Nitrogen fixation- anti cancer activity of platinum complexes (cisplatin and carboplatin).	12
References	3. Inorganic Chemistry, 4th edn., J.E. Huheey, E.A. Keither and R.L. Keiter, Harper Collins College Publisher, New York,1993. 4. Inorganic Chemistry, D.F. Shriver, P.W. Atkins and C.H. Langford, ELBS, Oxford University Press,2000. 5. Inorganic Chemistry, G. L. Miessler and D. A. Tarr, Pearson, Delhi,2009. 6. Principles of Organometallic Chemistry, P.Powell, Chapman and Hall, London,1988. 7. Concepts and Models of Inorganic Chemistry, B. Douglas, D.H. McDaniel and J.J. Alexander, John Wiley & Sons, New Delhi,2001.	
Course Outcomes	At the end of the course, students will be able to: ➢ Describe the chemistry of metal complexes and interpret the structure of metal carbonyls using IR spectral data. ➢ Select and integrate the chemistry of	

	metalloenzymes and the mechanical aspects of organometallics. ➢ Appreciate the chemistry of chains, rings, cages and clusters. ➢ Describe and evaluate the functions, mechanism of photosynthesis, enzymes and oxygen transport in biological systems.
References	
	Reference Books: 1. 2
	E-Resources 1. 2.
Course Outcomes	After completion of course the student will be able to CO1: Explain the chemistry of metal complexes and interpret the structure of metal carbonyls using IR spectral data. CO2: Select and integrate the chemistry of metallocenes and the mechanical aspects of organometallics CO3: Discuss the chemistry of chains, rings, cages and clusters. CO4: Explain and evaluate the functions, mechanism of photosynthesis, enzymes and oxygen transport in biological systems.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (1)	✓ (2)	✓ (1)	✓ (2)	
CO2	✓ (2)	✓(2)	✓ (1)	✓(2)	✓ (2)
CO3	✓ (2)	✓ (1)	✓ (2)	✓ (2)	
CO4	✓ (2)	✓ (1)		✓ (2)	

Semester	III	Course Code	**21CHEP0313**
Course Title	ORGANIC CHEMISTRY- III		
No. of Credits	3	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to understand stereochemistry of various organic compounds and synthetic uses of selected organic reagents. To know various strategies used in retro synthetic		

	analysis, the basic principles involved in mass spectrometry and also combined spectroscopy problems involving simple organic molecules. To understand the chemistry of selected alkaloids.	
UNIT	Content	No. of Hours
I	**Stereochemistry** R/S system on nomenclature of central and axially chiral molecules – atropisomerism, isomerism of biphenyls, allenes, spiranes, paracyclophanes and ANSA compounds – Geometrical isomerism – E/Z nomenclature – determination of configuration of geometrical isomers – asymmetric synthesis – substrate controlled methods, auxillary controlled methods, reagent controlled methods and catalyst controlled methods – chiral catalyst – Cram's rule – Prelog's rule. Topical relationship in organic molecules – Homotopic, enantiotopic, diastereotopic groups and faces, Pro R and S descriptors and Re and Si for ligands.	12
II	**Organic Reagents-II** Study of synthetic applications of the following reagents –n-BuLi, Et_2Zn, CBS-catalyst, EDCI, DCC, HATU, HOBT, CAN, TEMPO and IBX.	12
III	**Strategies in Organic Synthesis** An introduction of synthons and synthetic equivalents, disconnection approach, functional group interconversion of halides, nitriles, azides, amines, and esters -the importance of order of events in organic synthesis, nucleophilic and electrophilic synthons - umpolong reactions - typical examples of one group C-X and two group C-X disconnections – two group disconnections – 1,2-difunctionalised compounds – 1,3- - α, β-unsaturated carbonyl compounds – 1,4-difuctionalised compounds – Diels – Alder reactions and Micheal additions.	12
IV	**Mass Spectrometry and combined spectroscopic problems** Mass spectrometry: resolution – EI and CI methods – basic peak, isotopic peaks, meta-stable peak, parent peak, determination and use of molecular formula – recognition of molecular ion peak – fragmentations – general rules – pattern of fragmentation for various classes of compounds – McLafferty rearrangement – use of meta-stable peaks. Combined spectroscopy problems involving simple organic molecules and UV, IR, NMR and MS data	12
V	**Unit V – Alkaloids** Structural elucidation and synthesis of following alkaloids: atropine, quinine, reserpine and morphine.	12
References	1. A. J. Kirby, Stereoelectronic Effects, Oxford University Press, 1996. 2. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic	

	Compounds Wiley Student Edition, 2008. 3. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis-An Introduction, W. H. Freeman and Company, 2006. 4. W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, 4th edition Cambridge University Press. 5. E. J. Corey and X. M. Cheng, The Logics of Chemical Synthesis, Wiley, 1989. 6. K. C. Nicolaou, Classics in Total Synthesis, Vol 1, 2 and 3. 7. S. Warren and P. Wyatt, Organic Synthesis: The Disconnection Approach, 2nd edition, Wiley, 2008. 8. J. H. Fuhrhop, G. Li, Organic Synthesis: Concepts and Methods, 3rd edition, VCH, 1994. 9. W. Carruthers, Some Methods of Organic Synthesis, Cambridge University Press. 10. H. O. House, Modern Synthetic Reactions, Benjamin-Cummings Publishing Co. 2nd edition, 1972 11. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric identification of organic compounds, 7th edition, John Wiley, 2005. 12. Organic Spectroscopy, W. Kemp, 3rd edition, Macmillan, 2011. 13. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw Hill, 6th edition 2007. 14. D. L. Pavia and G. M. Lampman Spectroscopy 4th Edition, Brooks Cole, 2012. 15. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th edition, New age international, 2004. 16. I.L. Finar, Organic Chemistry, Vol.2 ELBS, 5th edition, 1974 and Pearson India, 5th edition, 2011.
Course Outcomes	At the end of the course, students will be able to: ➢ Assign R/S and E/Z nomenclature and analyze asymmetric synthesis and topical relationship in organic molecules. ➢ Assess the mechanism and synthetic uses of selected reagents and reactions. ➢ Describe the important concepts of the organic chemistry for the synthesis of new molecule, introduction of different functional group. ➢ Interpret mass spectral data Analyze and identify simple organic molecules by using UV, IR, Mass, ^{1}H NMR and ^{13}C NMR data. ➢ Elucidate the structure and plan for the synthesis of selected alkaloids.
References	Text Books (with chapter number & page number, wherever needed):

	1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of the course, the student will be able to CO1: Carry out the asymmetric synthesis CO2: Choose and employ the reagents for essential organic transformations CO3: To formulate the synthesis of organic compounds using disconnection approach CO4: To characterize organic compounds using mass spectrometric techniques CO5: To elucidate the structure of alkaloids.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓ (2)	✓ (2)	✓ (3)	✓ (1)
CO2	✓ (2)	✓ (3)	✓ (2)	✓ (3)	✓ (1)
CO3	✓ (2)	✓ (1)	✓ (2)	✓ (3)	✓ (1)
CO4	✓ (2)	✓ (2)	✓ (3)	✓ (3)	✓ (1)
CO5	✓ (2)	✓ (1)	✓ (2)	✓ (2)	✓ (1)

Semester	III	Course Code	**21CHEP0314**
Course Title	**Physical Chemistry–III**		
No. of Credits	3	No. of contact hours per week	3
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Advanced skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: Apply K-4: Analyse K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to understand the theories of		

	microwave, FT-IR, Raman, NMR, ESR and Mossbauer spectroscopic techniques, to know the principle and applications of molecular spectroscopy, and to understand the reactions at the solid surfaces.	
UNIT	Content	No. of Hours
I	**Molecular Spectroscopy I** Microwave spectroscopy: Rotation of molecules-Diatomic molecules- rigid and non-rigid rotators-intensities of spectral lines-effect of isotopic dilution-Polyatomic molecules-symmetric and asymmetric Top molecules-chemical analysis by microwave spectroscopy. FT -IR spectroscopy-theory-fundamental vibrations of diatomic and polyatomic molecules- classical theory of Raman effect, Rotational Raman spectra and vibrational Raman spectra.	12
II	**Molecular Spectroscopy II** Electronic spectroscopy-Born-Oppenheimer approximation-Franck-Condon principle, dissociation energy and dissociation products - predissociation-re-emission of energy, fluorescence and phosphorescence-photoelectron spectroscopy-basic principles- photoelectron effect, ionization process, photoelectron spectra of simple molecules. Mossbauer spectroscopy- basic principle-isomer shift, quadrupole splitting, magnetic field effect.	12
III	**Molecular Spectroscopy III** Nuclear magnetic spectroscopy-nuclear spin-nuclear relaxation-magnetic shielding and chemical shift, deshielding, spin-spin interactions-Nuclear Overhauser effect.Introduction to ^{13}C NMR-chemical shift-charge density calculation-broad band decoupling-off resonance decoupling and gated decoupling.Two-dimensional NMR-Basics. Electron spin resonance spectroscopy-basic principles, hyperfine splitting, zero field splitting and Kramer's degeneracy, factors affecting 'g' value	12
IV	**Surface Chemistry I** Adsorption and free energy changes at interfaces-solid-gas interface -Langmuir, BET isotherms-surface area determination-soluble and insoluble film-solid-liquid interfaces-Gibbs adsorption isotherm-contact angle and wetting-applications of adsorption. Role of surface in catalysis-semiconductor catalysis-n and p-type surfaces-kinetics of bimolecular surface reactions-	12

	Langmuir-Hinshel-Wood mechanism, Langmuir Rideal mechanism and Rideal-Eley mechanism.	
V	**Surface Chemistry II** Electrical aspects of surface chemistry-electrical double layers-Stren and diffuse layers. Zeta potential concept, determination and applications, electrophoresis, electroosmosis, sedimentation and streaming potential-micelles and reverse micelles, macro and micro emulsions.Principle, instrumentation and applications of ESCA, Auger, SEM, TEM, AFM spectroscopy.	12
References	1. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill, New York,1962. 2. Molecular Spectroscopy, C.N. Banwell and E.M. Mcash, Tata McGraw Hill, NewDelhi, 1983. 3. Vibrational Spectroscopy, Satyanarayana, New Age International,1997. 4. Physical Chemistry, P.W. Atkins, ELBS Edn.,1998. 5. Physical Chemistry of Surfaces, W. Adamson, John Wiley and Sons, 3rd Edn.,1976.	
Course Outcomes	At the end of the course, students will be able to: ➢ Describe the different theoretical aspects of spectroscopic techniques ➢ Identify the different photophysical processes ➢ Describe and evaluate the application of NMR and ESR techniques to different molecules. ➢ Explain the principle and instrumentation of surface characterization.	
References	Text Books (with chapter number & page number, wherever needed): 1. 2.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	After successful completion of the course students will be able to **CO1:** Describe the different theoretical aspects of spectroscopic techniques **CO2:** Identify different pathways in photochemical processess **CO3:** Describe and evaluate the application of magnetic resonance spectroscopic techniques (NMR & ESR) to different molecules **CO4:** Identify interfacial surface reactions **CO5:** Explain the principle and instrumentation of surface characterization techniques	

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (1)	✓ (2)	✓ (2)	✓ (1)
CO2	✓ (3)	✓ (1)	✓ (1)	✓ (2)	✓ (1)
CO3	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (2)
CO4	✓ (3)	✓ (3)	✓ (1)	✓ (3)	✓ (1)
CO5	✓ (3)	✓ (2)	✓ (2)	✓ (3)	✓ (1)

Semester	III	Course Code	**21 CHEP0315**
Course Title	INORGANIC CHEMISTRY PRACTICAL-II		
No. of Credits	2	No. of contact hours per week	5
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The practical course is designed to acquire skills in inorganic quantitative estimation methods and to get trained in simple quantitative methods of analysis of inorganic compounds.		

Content	No. of Hours
1. Gravimetric analysis – Estimation of mixture of copper and nickel 2. Gravimetric analysis – Estimation of mixture of calcium and barium 3. Colorimetric analysis – Estimation of copper 4. Analysis of cement 5. Analysis of alloys (brass and solder) 6. Estimation of calcium and magnesium in plant samples. 7. Preparation and analysis of a coordination complex. 8. Estimation of pharmaceutical preparations (Paracetamol, Cimetidine) 9. Analysis of iron ore. 10. Estimation of Composition of a complex by Job's method. 11. Colorimetric determination of stability constant of a complex 12. Analysis of a fungicide.	60

References	
	1. Vogel's Text book of quantitative Chemical analysis, G.H. Jaffery, J. Bassett, J. Mendhan and R.C. Deeny. ELBS,1997.

	2. Analytical Chemistry in Metallurgy, V.I. Posypaiko and N.A. Vasiua, Mir Publisher, Moscow,1984.
Course Outcomes	At the end of the practical course, students will be able to: ➢ *Estimate the metals and alloys by using quantitative methods.* ➢ *Analyze the ores and pharmaceutical preparations quantitatively*
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to . CO1: *Estimate the metals and alloys by quantitative methods* CO2: *Analyze the ores and pharmaceutical preparations quantitatively.*

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓(3)	✓ (3)	✓ (3)	✓ (3)
CO2	✓ (1)	✓(3)	✓ (3)	✓ (3)	✓ (3)

Semester	III	Course Code	**21CHEP0316**
Course Title	ORGANIC CHEMISTRY PRACTICAL-II		
No. of Credits	2	No. of contact hours per week	5
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The practical course is designed to acquire skills in estimation and multistep synthesis by using various		

	organic reactions and to resolve racemic compounds and synthesize of organic compounds using green methods
Content	No. of Hours
1. Determination of saponification value of edible oil 2. Determination of iodine value of edible oil 3. Determination of FFA of an oil sample 4. Multistep synthesis of organic compounds involving 5. Resolution of racemic compounds. 6. Green synthesis and multi-component synthesis of selected compounds.	60
References	1. Vogel's Text Book of Practical Organic Chemistry, Furniss, S. B.; Hannaford, A. J.;Smith, P. W. G.; Tatchell, A. R. Longman Scientific & Technical, 5th Edn., England,1989. 2. Laboratory Manual of Organic Chemistry, Dey and Sitaraman, Allied Publishers, 1992.
Course Outcomes	At the end of the practical course, students will be able to: ➢ Estimate the metals and alloys by using quantitative methods. ➢ Analyze the ores and pharmaceutical preparations quantitatively
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to . CO1: *Estimate the selected organic compounds, predict FFA, saponification value, iodine value of oil samples and identify the intermediates and organic compounds* CO2: *Resolve racemic mixtures, organic compounds and plan for green synthesis and, multi- component synthesis of organic compounds.*

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓(3)	✓ (3)	✓ (3)	✓ (2)
CO2	✓ (2)	✓(3)	✓ (3)	✓ (3)	✓ (2)

Semester	III	Course Code	21CHEP03D5
Course Title	SUPRAMOLECULAR CHEMISTRY		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to provide a concise introduction and applications of supramolecular chemistry.		

UNIT	Content	No. of Hours
I	**Supramolecular interactions and molecular receptors** Supramolecular interactions: Ion-ion, Ion-dipole, dipole-dipole, hydrogen bonding, cation-π, anion-π, π-π, van der Waals interactions. Structural aspects of molecular receptors: Tweezers, crown-ethers, cryptands, carcerands, cucurbit[n]urils, cycophanes, cyclodextrins and calixarenes.	12
II	**Analytical methods in supramolecular chemistry** Studies on supramolecular interactions using ^{1}H-NMR and UV-vis titration techniques, Isothermal Titration Colorimetry (ITC), Crystallography, Dynamic Light Scattering (DLS) and Mass Spectrometry.	12
III	**Molecular recognition of cations, anions and neutral molecules** Molecular recognition of cations by crown-ethers and calixarenes. Molecular recognition of Anions: Anion binding interactions, Challenges in the design of Anion receptors, factors which affect anion complexation, Hofmeister series, examples of neutral tripodal anion receptors and Calixpyrroles as anion receptors. Molecular recognition of Neutral guests - Hamilton's barbiturate receptor, Hunter's quinone, Rebek's tennis balldimer.	12
IV	**Crystal Engineering Using Multiple Hydrogen Bonds** Language of crystal engineering: supramolecular synthon – hydrogen bond donors and acceptors. Systems	12

	Based on DA-AD interactions: Synthons involving Pairs of OH…O, NH…O, OH…N and NH…N hydrogen bonding interactions. Systems based on DD-AA interactions: Guanidinium nitrate and Guanidinium sulfonates. Systems Based on ADA-DAD Interactions: hexagonal melamine - cyanuric acid hydrogen-bonded array.	
V	**Applications of supramolecular chemistry** Supramolecular catalysis: Fujita's M4 L6-assembly- unusual [2+2] and [4+2] cycloaddition. Supramolecular polymers - Main chain supramolecular polymers, side-chainsupramolecular polymers, examples of stimuli responsive supramolecular polymers and self-healingpolymers.	12
References	1. Supramolecular Chemistry - A Concise Introduction, J. W. Steed and J. L. Atwood, John Wiley,2000. 2. Modern Supramolecular Chemistry-Strategies for Macrocycle Synthesis, Ed: François Diederich, Peter J. Stang and Rik R. Tykwinski, Wiley-VCH Verlag GmbH & Co.,2008. 3. Organic Nanostructures. Ed: Jerry L. Atwood and Jonathan W. Steed, Wiley-VCH Verlag GmbH & Co.,2008. 4. Supramolecular Chemistry of Anions, Ed: Antonio Bianchi, Kristin Bowman James and Enrique Garcia-España, Wiley-VCH1997. 5. Anion Receptor Chemistry. Ed: Jonathan L. Sessler, Philip A. Gale and Won-Seob Cho, RSC Publishing, 2006. 6. Analytical Methods in Supramolecular Chemistry. Ed: Christoph Schalley, Wiley-VCH Verlag GmbH & Co.,2007. 7. Crystal engineering using multiple hydrogen bonds, In Structure and Bonding, Ed: Andrew D. Burrows, Vol. 108, 55-96, 2004. 8. Supramolecular polymers. Ed: Alberto Ciferri, 2nd Edn., CRC Press,2005.	
Course Outcomes	At the end of the course, students will be able to: ➢ Describe about various supramolecular interactions and topological aspects of molecular receptors. ➢ Uses of various analytical methods in supramolecular chemistry.	

	➢ Identify and design receptors for cationic, anionic and neutral molecules. ➢ Describe about multiple H-bonding interactions used in crystal engineering. ➢ Apply supramolecular chemistry in appropriate fields
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of the course students will be able to **CO1**: Describe various supramolecular interactions and topological aspects of molecular receptors. CO2: Select suitable analytical method to study supramolecular interactions. **CO3**: Identify and design artificial receptors for cations, anions and neutral molecules. **CO4**: Analyze hydrogen bonding interactions from X-ray crystallographic data. **CO5:** Outline the applications of supramolecular chemistry.

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (1)	✓ (2)		✓ (2)	
CO2				✓ (2)	
CO3	✓ (1)	✓ (2)			
CO4	✓ (1)			✓ (2)	
CO5	✓ (1)		✓ (2)		✓ (2)

Semester	III	Course Code	**21CHEP03D1**
Course Title	POLYMER CHEMISTRY		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course	Basic Skill		

(may be more than one)		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:	
Course Objectives (Maximum.5)	The objective of the course is to stress the importance of polymers, to understand various polymerization techniques and characterization of polymers, to understand polymer structure, properties and to know the polymer processing techniques, and the chemistry of commercially available polymers and polymer additives.	
UNIT	Content	No. of Hours
I	**Types and Chemistry of Polymerization** Classification of polymers, Types of polymerization – addition, free radical, ionic and coordination polymerization – Ziegler-Natta Catalyst, Stereo regular polymerization, Condensation polymerization – Mechanism and Kinetics of addition and condensation polymerization – degree of polymerization – kinetic chain length – factors affecting chain polymerization-inhibition and retardation – Carother's equation- Polymerisation techniques-bulk, solution, suspension and emulsion polymerization.	12
II	**Copolymerization and Polymerization Techniques** Types of copolymers- ideal, alternating, block and graft copolymer – Types of copolymerization – Free radical ionic copolymerization –polycondensation – copolymer equation – significance – monomer and radical reactivity – Q-e scheme - Determination of monomer reactivity ratio – Mayo-Lewis and Fineman Ross methods – block and graft copolymerization – methods of preparation and mechanism.	12
III	**Polymer Characteristics and Characterization** Types of degradation – thermal, mechanical and photodegradations - Green methods of management of plastics in the environment. Polymer purification - separation of polymers – precipitation and isolation by gel permeation chromatography. The concept of number average and weight averages. Molecular weight methods - Molecular weight distribution, - determination of molecular weights –	12

	Osmotic pressure, light scattering, viscosity and end group analysis, ultra centrifugation methods. Analysis and testing of polymers- physical / mechanical and chemical analysis of polymers – spectroscopic methods, x-ray diffraction study.	
IV	**Structure, Properties and Fabrication of Polymers** Morphology and order in crystalline polymers – configurations of polymer chain –types of stereo isomerism in polymer – tacticity (eg. Mono and disubstitute polyethylene, polypropylene, polybutadiene) significance of stereoregularity. Polymer structure and physical properties – crystalline melting point Tm – melting points of homogeneous series – effect of chain flexibility and heat of fusion. The glass transition temperature, Tg-relationship between Tm and Tg, effects of molecular weight,chemical structure, property requirements and polymer utilization. Fabrications of polymers – Moulding, casting, calendering and spinning of polymers.	12
V	**Chemistry of Commercial Polymers and Polymer Additives** Organic polymers polyethylene, polyvinyl chloride, polytetrafluoroethylene, polyamides, polyesters, phenolic resins, epoxy resins. Dendrimers – Types and applications.poly (organophosphazenes) polymers, Inorganic polymers – silicon polymers, glass, Basic concept of conducting polymers, liquid crystal polymer, biopolymer and biomedical polymer. Polymer additives: Fillers, plasticizers, colourants, anti oxidants, fire retardants and thermal stabilizers – polymer blends and composites.	12
References	1. Text book of polymer science, F.W. Billmeyer Jr. 3rdEdn., Wiley, India2007. 2. Polymer science, V.R. Gowarikar, N.V. Viswanathan, New age international,2003. 3. Principles of polymerization, George Odian, 4th Edn., John wiley and sons,2007. 4. Polymer science and technology, Goel R. Fried, Prentice – Hall of India, New delhi, 2000. 5. Polymer science and technology of	

	plastics and rubbers, P. Ghosh, Tata McGraw-Hill, New Delhi,1998. 6. Introductory polymer chemistry, G.S. Misra, Wiley eastern Ltd.,1993.
Course Outcomes	At the end of the course, students will be able to: ➢ Describe the principles and concepts of contemporary polymer chemistry. ➢ Explain the basic concepts of polymer synthetic techniques. ➢ Analyze the basic reactions in polymer chemistry. ➢ Describe the physical properties of different polymers. ➢ Characterize the polymers by using various experimental techniques
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After Successful completion of the course students will be able to CO1: Compile the basic concepts of polymer and the chemistry of polymerization CO2: Demonstrate the types of copolymer and techniques of polymerization CO3: Analyze the characteristics of polymers using various experimental techniques CO4: Discuss the structure, properties and fabrication of polymers CO5: Assess the chemistry of organic, inorganic polymers and polymer additives

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)				
CO2		✓ (2)		✓ (1)	✓ (1)
CO3		✓ (1)		✓ (1)	
CO4	✓ (1)		✓ (1)		✓ (1)
CO5				✓ (1)	

Semester	III	Course Code	21CHEP03M1
Course Title	ADVANCED FUNCTIONAL MATERIALS		
No. of Credits	2	No. of contact hours per week	2
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to provide a comprehensive introduction of molecular –level devices, machines, to understand the structural and biological properties of dendrimers, to understand the principles of high temperature superconductors, to understand the importance of biodegradable polymers and to understand the principles and concepts of smart polymers.		
UNIT	Content		No. of Hours
I	**Molecular Level Devices-I** Supramolecular interactions – Molecular machines in biological systems – Introduction to synthetic molecular machines		6
II	**Molecular Level Devices-II** Mechanically interlocked molecules – Pseudorotaxanes – Rotaxanes – Catenanes – Molecular shuttles – Molecular Pumps – Molecular muscles		6
III	**Dendrimers Poly(amidoamine) Dendrimer-Based Multifunctional Nanoparticles** Introduction to dendrimers – Synthesis of dendrimers – convergent synthesis – divergent synthesis - PAMAM Dendrimers: Structure and biological properties		6
IV	**Optical and Photonic Functional Materials** Optical Materials - optical properties, such as photonic crystals, luminescent materials (quantum dots), and nonlinear optical materials - Applications in imaging and sensing technologies. Photonic Devices: Study of devices based on optical materials, including lasers, light-emitting diodes (LEDs), optical fibers - sensors. Principles of operation - roles in telecommunications and imaging.		6

V	**Smart and Functional Coatings** Smart Coatings: Overview of coatings that exhibit responsive properties, including self-healing coatings, anti-corrosive coatings, and adaptive coatings. Applications in various industries, such as aerospace and automotive. Functional Coatings: Study of coatings designed to provide specific functionalities, such as hydrophobic (water-repellent), oleophobic (oil-repellent), and antimicrobial properties. Methods for application and characterization of these coatings.	6
References	1. Molecular-Level Devices and Machines, In Stimulating Concepts in Chemistry, Ed., Fritz Vögtle, J. Fraser Stoddart and Masakatsu Shibasaki, pp 255-266, Wiley-VCH Verlag GmbH, Weinheim,2000. 2. Poly(amidoamine) Dendrimer-Based Multifunctional Nanoparticles, In Nanobiotechnology II, Ed: Chad A. Mirkin and Christof M. Niemeyer, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim,2007. 3. Polymers and Ecological problems, Ed., J. Guillet, Plenum Press, New York,1973. 4. Polymer Degradation – Principles and Practical Applications, W. Schnabel, Hanser International,1981. 5. Self-Healing Polymers via Supramolecular, Hydrogen-Bonded Networks, in Self- healing Polymers: From principles to applications, Ed: Wolfgang H. Binder, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany,2013.	
Course Outcomes	At the end of the course, students will be able to: o *Describe the molecular-level devices and machines.* o *Predict molecular devices based on various supramolecular interactions.* o *Propose the synthesis, characterization and application of PAMAM dendrimers.* o *Identify the optical*	
References	Text Books (with chapter number & page number, wherever needed): 1. 2.	
	Reference Books: 1.	

	2.
	E-Resources 1. 2.
Course Outcomes	○ After successful completion of the course students will be able to *Describe the molecular-level devices and machines.* ○ *Predict molecular devices based on various supramolecular interactions.* ○ *Propose the synthesis, characterization and application of PAMAM dendrimers.* ○ *Identify the optical and photonic functional materials and smart coatings*

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (1)			✓ (2)	
CO2	✓ (1)		✓ (2)	✓ (2)	
CO3	✓ (1)		✓ (2)	✓ (2)	
CO4	✓ (1)			✓ (2)	
CO5	✓ (1)		✓ (2)	✓ (2)	✓ (2)

Semester	III	Course Code	21CHEP03M2
Course Title	NANOTECHNOLOGY AND ITS APPLICATIONS		
No. of Credits	2	No. of contact hours per week	2
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to enable students to get an introductory idea of some of the fundamentals and current state –of -the art of nanotechnology and to get familiarize with the synthesis, characterization and applications of nanomaterials.		
UNIT	Content		No. of Hours
I	**Introduction to Nanoscience** Definition of terms-nanoscale, nanomaterials, nanoscience,		6

	nanotechnology-scale of materials natural and manmade-nanoscience practiced during ancient and modern periods- contributors to the field of nanoscience.	
II	**Synthesis of Nanomaterials** Top down and bottom up approaches-synthesis of carbon nanotubes, quantum dots, gold and silver nanoparticles. Techniques such as chemical reduction, template-assisted synthesis, and hydrothermal methods.	6
III	**Properties and Characterization of Nanomaterials** Structural Nanomaterials: Study of nanostructured materials - carbon-based nanomaterials (graphene, carbon nanotubes) - metal and semiconductor nanomaterials - Properties such as mechanical strength, electrical conductivity, and thermal behavior. Optical and Magnetic Nanomaterials: Examination of nanomaterials with unique optical and magnetic properties, including quantum dots, plasmonic nanoparticles, and magnetic nanoparticles. Applications in imaging, sensing, and data storage. Electron microscopy techniques-scanning electron microscopy, transmission electron microscopy and atomic force microscopy.	6
IV	**Application of Nanomaterials** Solar cells-smart materials-molecular electronics-biosensors-drug delivery and therapy-detection of cancerouscells. Energy Conversion and Storage: Environmental Remediation	6
V	**Nanotechnology in Nature** The science behind the nanotechnology in lotus effect-selfcleaning property of lotus- gecko footclimbing ability of geckos-water strider-antiwetting property of water striders-spider silkmechanical properties of the spider silk.	6
References	1. Nano: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw-Hill Professional Publishing,2008. 2. Introduction to Nanoscience, J. Dutta, H.F. Tibbals and G.L. Hornyak, CRC press, Boca Raton,2008.	

Course Outcomes	At the end of the course, students will be able to: ➢ Appreciate the state of the art developments in the field of nanotechnology. ➢ Identify common themes across nanotechnology. ➢ Predict the major properties of nanoobjects such as nanotubes, quantum dots and nanoparticles.
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of course the student will be able to CO1: *Appreciate the state of the art developments in the field of nanotechnology.* CO2: *Identify common themes across nanotechnology.* CO3: *Predict the major properties of nano objects such as nanotubes, quantum dots and nanoparticles.*

Mapping of COs with PSOs:

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (2)	✓(3)	✓ (3)	✓ (3)	✓ (2)
CO2	✓ (2)	✓(3)	✓ (3)	✓ (3)	✓ (2)
CO3	✓ (1)	✓(2)	✓ (2)	✓ (1)	✓ (2)

Semester	IV	Course Code	21CHEP0418
Course Title	INORGANIC CHEMISTRY – IV		
No.of Credits	4	No. of contact hours per week	4 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5:		

	K-6:	
Course Objectives (Maximum.5)	The objective of the course is to understand the basics of nuclear chemistry, types of nuclear reactions and its applications, to know the chemistry and reactions of non-aqueous solvents, to learn the basic principle, reactions and applications of photochemical processes and to have an idea about the general characteristics of f-blockelements.	
UNIT	Content	No. of Hours
I	**Nuclear Chemistry I** Nuclear models – Shell model – Liquid drop model - Types of radioactive decay – Alpha decay – Theory of alpha decay - The tunnel effect - Beta decay – Types of beta decay - Electron capture - Dirac's theory - Nuclear deexcitation – Artificial radioactivity. Nuclear reactions: Bathe's notation – Types of nuclear reactions - Elastic and inelastic scattering – Cross section - Q value – Transuraniens - Photonuclear reaction - Radioactive capture - Evaporation and spallation – Buckshot hypothesis - Thermonuclear reactions – Nuclear fusion - Nuclear fission – Fission fragments - Mass and charge distribution – Fission energy.	8 Hours
II	**Nuclear Chemistry II** Breeder reactor – Counting techniques: G.M., Ionization and Proportional counter. Applications of radioisotopes – Esterification – Friedal Craft's reaction – Structural determination of PCl5 - Solubility of sparingly soluble substance – Isotope dilution analysis – Carbon dating – Thyroiditis - Assessing the volume of blood in a patient - Brain tumor location and bone fracture healing- Optimum use of fertilizers - Control of predatory insects - Prospecting of water and petroleum	8 Hours
III	**Non-aqueous Solvents** Acid-base, Metathetical, Solvolysis and Redox reactions in liquid ammonia - Hydrogen fluoride - Sulphuric acid and acetic acid solvents- Metal-ammonia solutions - Chemical reactions in liquid sulphur dioxide and phosphoryl chloride.	6 Hours
IV	**Inorganic Photochemistry** Principle of light absorption – physical and chemical processes –bimolecular reactions- Stern-Volmer relationship- Properties of d-d, d-π^*, π - $\pi^*$and π -d energy states. Photochemical reactions of metal complexes – substitution- Admson's rules- rearrangement– isomerisation– racemisation– aquation	8 Hours

	and anation – redox reactions. Rutheniumpolypyridyls - excited state properties – electron transfer and energy transfer quenching reactions – importance of solar energy conversion and storage – cleavage of water using Ru(bpy)32+, Cadmium sulphide colloidal particles and titanium dioxide semiconductor –[Ru(edta)H2O] catalyzed ammonia production.	
V	**Coordination Chemistry of Lanthanides and Actinides** General characteristics of lanthanides-Electronic configuration-Oxidation state- Lanthanide contraction-Lanthanide contraction and its consequences-extraction- ion exchange and solvent extraction methods-Term symbols for Lanthanide ions (Derivation not required)- Factors that mitigate against the formation of lanthanide complexes-Electronic spectra and magnetic properties of lanthanide complexes-Lanthanide complexes as shift reagents- Difference between 4f and 5f orbitals-Comparative account of coordination chemistry of lanthanides and actinides with special reference to electronic spectra and magnetic properties.	6 Hours
References		
Course Outcomes	➢ Describe the basic concepts of nuclear chemistry and types of nuclear reaction. ➢ Predict the chemistry and reactions of non-aqueous solvents. ➢ Describe the photochemical processes of inorganic molecules. ➢ Examine the general characteristics of f- block elements and analyze the electronic and magnetic properties of their complexes	
References	Text Books (with chapter number & page number, wherever needed): 1. Essential of Nuclear Chemistry, H.J. Arnikar, Wiley-Eastern Ltd., Delhi,2001. 2. Nuclear and Radiochemistry, G. Freindlander, J. W. Kennedy, E.S. Macias, and J. M. Miller, John Wiley and Sons, New York,1991. 3. Inorganic Chemistry, 4thEdn, J.E. Huheey, E.A. Keither and R.L. Keiter, Harper Collins College Publisher, New York,1993. 4. Inorganic Chemistry, D.F. Shriver, P.W. Atkins and CH. Langford, ELBS, Oxford University Press,2000. 5. Fundamentals of Photochemistry, K.K.Rohatgi Mukherjee, New Age International Publisher, New Delhi, 2006	

	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	On completion of the course, students should be able to do CO1: Outline the basic concepts of nuclear chemistry and types of nuclear reaction. CO2: Predict the chemistry and reactions of non-aqueous solvents. CO3:Explain the photochemical processes of inorganic molecules. CO4: Discuss the general characteristics of f- block elements and analyze the electronic and magnetic properties of their complexes

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (1)		✓ (1)	✓ (2)	
CO2	✓ (3)		✓ (1)		✓ (1)
CO3	✓ (2)	✓ (1)	✓ (1)	✓ (1)	
CO4	✓ (2)	✓ (1)		✓ (3)	

Semester	IV	Course Code	21CHP 0419
Course Title	ORGANIC CHEMISTRY - IV		
No.of Credits	4	No. of contact hours per week	4 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to enable students to know various reaction mechanism involving photochemistry and pericyclic reactions. To understand organic synthesis using protection deprotection strategies and green chemistry and also to know the chemistry of steroids and proteins.		
UNIT	Content		No. of Hours

I	**Organic Photochemistry** Fundamental concepts, Jablonski diagram – energy transfer – characteristics of photo reactions – photo reductions and photo oxidation – photoreactions of carbonyl compounds – Norrish type I and Norrish type II reactions, di-pi methane rearrangement – photochemistry of arenes, photochemistry of alkenes, cis-trans isomerisation – rearrangements of cyclic – unsaturated ketones and 2,5-cyclohexadienone – Barton reaction – Paterno Buchi reaction.	8 Hours
II	**Pericyclic Reactions** Pericyclic reactions: Concerted reactions – orbital symmetry and correlation diagram approach – FMO and PMO approach, Woodward-Hofmann rules – Electrocyclic reactions (1,3-butadiene-cyclobutene and 1,3,5-hexatriene-cyclohexadiene systems) – cycloadditions [2+2] and [2+4] systems (ethylene-cyclobutane, ethylene and 1,3-butadiene-cyclohexene systems) – selection rules – cycloreversion (reterocycloaddition reactions) – 1,3-dipolar cycloaddition - sigmatropic rearrangements – Sommelet-Hauser, Cope, Fries and Claisen rearrangements.	8 Hours
III	**Protection and Deprotection Chemistry in Organic Synthesis** Protection and cleavage of hydroxyl groups (by ethers)-MOM-Cl, MEM-Cl, THP, Allyl, Benzyl, TBDMS,Protection and cleavage of hydroxyl groups (by esters)-Trichloroacetate, Phenoxyacetate, Pivaloate, 2,4,6-trimethylbenzoate; Protection and cleavage of1,2 and 1,3- Diols-methylene dioxy derivative:Methoxymethyleneacetal, ethyledineacetal, cyclic carbonates; Protection and cleavage of carbonyl groups- 1,3-Dioxanes, 1,3-dithianes, 2,4- dinitrophenylhydrazones; Protection and cleavage of Amino groups-Boc, CBz, Fmoc, N-Acetyl, N-Benzyl.	6 Hours
IV	**Green chemistry** Green Chemistry: Designing a green synthesis, basic principles of green chemistry- Atom economy-Phase transfer catalyst, crown ethers- synthesis and applications, Quaternary ammonium	8 Hours

	salts, polymer supported reagents, ionic liquids and principles and applications of Sono chemistry	
V	**Steroids and proteins** Chemistry of Cholesterol (Structural Elucidation) – Conversions of cholesterol to Androsterone, Testosterone, Progesterone. **Proteins:** Structure of Proteins-End group analysis-Primary, Secondary, Tertiary and Quaternary Structure of protein. Solid peptide synthesis-Merrifield resin-Chemistry and structure of oxytocin.	6 Hours
References		
Course Outcomes	➢ Evaluate concerted reactions via FMO and PMO approach, Electrocyclic reactions, cycloadditions and sigmatropic rearrangements.. ➢ Formulate the chemistry of protection and de-protection strategies involved in hydroxyl group by ether and ester, carbonyl group, and amino groups and elementary idea of PTC, microwave and sonochemistry. ➢ Describe the chemistry and structure of cholesterol and oxytocin.	
References	Text Books (with chapter number & page number, wherever needed): 1. J. D. Coyle, Introduction to Organic Photochemistry, Wiley, 1991. 2. B. Halton, J. M. Coxon, Organic Photochemistry, Cambridge University Press, 2011. 3. S. Sankararaman, Pericyclic Reactions: A Textbook: Reactions, Applications and Theory, Wiley-VCH, 2005. 4. C.H. DePuy and O.L. Chapman, Molecular Reactions and Photochemistry, Prentice-Hall, New Delhi, 1987. 5. Theodora W. Greene and Peter G. M. Wuts Protective Groups in Organic Synthesis:, John Wiley & Sons, Inc.,3rdEdn., 1999. 6. V.K. Ahluwalia, Renu Aggarwal, Organic Synthesis Special Techniques, Narosa publishing House, 2004. 7. I.L. Finar, Organic Chemistry, Vol.2 ELBS, 5th edition, 1974 and Pearson India, 5th edition, 2011.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	On completion of the course, students should be able to do	

	CO1: Discuss the important concepts of the organic chemistry for the synthesis of new molecule, introduction of different functional group. **CO2**: Assess the synthetic uses of selected organic reagents and effect organic reactions with these reagents. **CO3**: Formulate the chemistry of protection and de-protection strategies involved in hydroxyl group by ether and ester, carbonyl group, and amino groups **CO4**: Develop methods for the synthesis and conversions of cholesterol and oxytocin. **CO5**: Assess the structure of proteins

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (2)	✓ (1)	✓ (2)	✓ (2)	
CO2	✓ (2)			✓ (2)	
CO3	✓ (2)	✓ (1)			
CO4	✓ (1)			✓ (2)	
CO5	✓ (1)		✓ (2)	✓ (2)	

Semester	IV	Course Code	21CHEP0420
Course Title	PHYSICAL CHEMISTRY - IV		
No.of Credits	4	No. of contact hours per week	4 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Advanced Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: Apply K-4: Analyse K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to give an in-depth account of different theories of statistical thermodynamics and chemical kinetics including the fast reactions.		
UNIT	Content		No. of Hours
I	**Statistical Thermodynamics I** Scope of statistical thermodynamics-probability theorem-phase space, microstate and macrostate, configuration, system, assembly and ensemble-different types of ensembles-permutations and combinations, thermodynamic probability, Maxwell-Boltzmann statistics and its limitations.		8 Hours

	Concept of partition functions, evaluation of translational, rotational, vibrational and electronic partition functions. Sackur-Tetrode equation- thermodynamic properties of monoatomic gases.	
II	**Statistical Thermodynamics II** Bose-Einstein statistics-Fermi-Dirac statistics-comparison of the three statistics-Application of Fermi-Dirac statistics to electron gas in metal-Application of Bose-Einstein statistics to photon gas-use of partition functions for obtaining thermodynamic functions – Gibbs free energy entropy and probability Boltzmann Planck's equation statistical approach to third law of thermodynamics and exception of this law – molar partition function – specific heat of solids – Einstein theory of specific heat – Debye theory	8 Hours
III	**Chemical Kinetics I** Theories of reaction rates-Collision theory and transition state theory, Comparison of collision theory with transition state theory, Arrhenius equation- characteristics, Significance of energy of activation, Temperature coefficient and its evaluation. Thermodynamic formulation of absolute reaction theory Lindeman's theory of unimolecular reactions, Marcus theory of electron transfer process.Derivations of rate constants for opposing, consecutive and parallel reactions steady state approximation.	6 Hours
IV	Chemical Kinetics II Kinetics of reactions involving reactive atoms and free radicals - Rice-Herzfeld mechanism and kinetics of organic gas phase decompositions (acetaldehyde & ethane); Kinetics of chain reactions-branching chain and explosion limits (H2-O2 reaction as an example). Factors influencing reaction rate in solution, significance of dielectric constant, salt effect, and kinetic isotope effect. Oscillatory reactions.	8 Hours
V	**Chemical Kinetics III** Concept of linear free energy relationships-thermodynamic implications of LFER-Catalysis- kinetics of homogeneously catalyzed reactions, mechanism of acid-base catalysis. Comparison of enzyme catalysed and chemicalcatalysed reactions, Mechanism (Lock and Key theory). Experimental methods for the study of fast reactions-flow method-chemical relaxation methods, T-jump and P-jump methods, ultrasonic absorption techniques, reaction in a flow system, continuous and stopped flow, shock wave	6 Hours

	tube method. Flash methods-nuclear magnetic resonance method.	
References		
Course Outcomes	➢ Describe the role of rotational, vibrational and electronic partition functions. ➢ Apply different statistical methods ➢ Predict the rate of the reaction and the influence of solvent and ionic strength. ➢ Analyze fast reactions by flow, flash and NMR methods .	
References	Text Books (with chapter number & page number, wherever needed): 1. Physical Chemistry, R. Stephen Berry, S.J. Rice, 2. Chemical Kinetics and Dynamics, J.J. Steinfeld, J.S. Franciso and W.L. Hase, 2nd edn., Prentice Hall, New Jersey, 1999. 3. Physical Chemistry, P. W. Atkins, Oxford University Press,1998.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	On completion of the course, students should be able to do CO1: Describe the role of translational, rotational, vibrational and electronic partition functions CO2: Analyze the different statistical thermodynamic methods and apply the partition functions for obtaining thermodynamic functions CO3: Discuss various theories to explain the kinetics of reactions CO4: Predict the rate of the reaction and the influence of solvent and ionic strength CO5: Analyze fast reactions by flow, flash and NMR methods	

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (3)	✓ (1)	✓ (1)	✓ (1)	✓ (1)
CO2	✓ (2)	✓ (1)	✓ (2)	✓ (1)	✓ (1)
CO3	✓ (3)	✓ (3)	✓ (2)	✓ (1)	✓ (1)
CO4	✓ (3)	✓ (1)	✓ (3)	✓ (1)	✓ (1)
CO5	✓ (3)	✓ (2)	✓ (3)	✓ (2)	✓ (1)

Semester	IV	Course Code	21CHEP04M1
Course Title	MOLECULAR ELECTRONICS AND ORGANIC PHOTOVOLTAICS		
No.of Credits	2	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Modular Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to get an introductory idea of molecular electronics, to know about molecular devices and their functions, to learn the methods to fabricate and probe molecular devices and to understand the basics of organic photovoltaics.		
UNIT	Content		No. of Hours
I	**Molecular Electronics – I** Conventional electronics and Its boundaries - Transistor development and Moore's Law- Definition of molecular electronics- -Molecular connectivity- Self assembling techniques.		4 Hours
II	**Molecular Electronics – I** Molecular devices: Molecular rectifiers- Molecular resistor-Molecular diode-Three terminal devices - Molecular transistor- Molecular single electron transistor-Molecular wires. Molecular memory devices and data Storage - Molecular switches –Optoelectronic devices		6 Hours
III	**Molecular Electronics - III** Logic devices-Tools and methods to build and probe molecular devices- Break-junction technique- Forming nanogaps with electromigration. Probing individual molecules- Contact resistance vs. quantized conductance. Integration strategies: Defect tolerance and new molecular architectures.		4 Hours
IV	**Organic Photovoltaics** Basics of organic solar cells – types of organic solar cells –heterojunction – bulk heterojunction - components of organic solar cells - light absorbing materials – p-i-n concept – tandem cells - cell fabrications. Dye sensitized solar cells -history – operational principles - absorption of light bymolecules.		4 Hours
V	**Characterization and Applications** Advanced characterization techniques for assessing device performance and stability, including photovoltaic quantum efficiency,		6 Hours

	transient absorption spectroscopy, and impedance spectroscopy. Exploration of current and potential applications, including flexible electronics, wearable devices, and renewable energy technologies.	
References		
Course Outcomes	➢ Describe the basics of molecular electronics. ➢ Plan for the fabrication of molecular devices. ➢ Identify the methods of probing individual molecules.	
References	Text Books (with chapter number & page number, wherever needed): 1. Molecular Electronics - Commercial Insights, Chemistry, Devices, Architectureand Programming by James M Tour,2003, First Edition, World Scientific Publishing Company,Singapore. 2. Molecular Electronics - An Introduction to Theory and Experiment by Juan Carlos Cuevas and ElkeScheer, 2010, First Edition, World Scientific Publishing Company, Singapore. 3. Introducing Molecular Electronics by Cuniberti, Gianaurelio, Fagas, Giorgos, Richter, Klaus (Eds.), 2005, Springer Publishing, Chennai. 4. Third Generation Photovoltaics Advanced Solar Energy Conversion, Martin A. Green, Springer, 1st ed.2003.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	On completion of the course, students should be able to do CO1: Describe the basics of molecular electronics. CO2: Plan for the fabrication of molecular devices. CO3: Identify the methods of probing individual molecules. CO4: Explain the organic photovoltaics	

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (3)	✓ (1)	✓ (2)	✓ (1)	✓ (1)
CO2	✓ (2)	✓ (2)	✓ (2)	✓ (1)	✓ (2)
CO3	✓ (1)	✓ (1)	✓ (1)	✓ (3)	✓ (2)
CO4	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (3)

Semester	III	Course Code	21CHEP03D2
Course Title	PHYSICAL ORGANIC CHEMISTRY		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to enable students to have an understanding of kinetics of chemical reactions, concepts of solvent effect on reaction rates, the basics of catalysis and correlation analysis.		

UNIT	Content	No. of Hours
I	**Principles of Kinetics** Mechanistic significance of entropy, enthalpy and Gibbs free energy.Arrhenius equation.Transition state theory.Uses of activation parameters.Analogies between kinetics and themodynamics.The concept of transition states.Rapid equilibria among transition states.Reactivity and selectivity principles.	12
II	**Linear free energy relationships** The Hammett equation, substituent constants, interpretation of s-values.Reaction constant.Deviations from Hammett equation.Dual-Parameter correlations, inductive substituent constant. The Taft model, S 1 and SR scales. The Swain-Lupton treatment.The ortho effect.Primary and secondary kinetic isotope effect.Heavy atom isotope effect.Tunneling effect.	12
III	**Principles of Solvent effect** The concept of solvation and preferential solvation.Solvation model.Qualitative theory of the influence of solvent on reaction rate.Thermodynamic measure of solvation.Effects of solvation on reaction rates and equilibria. Various empirical indexes of solvation based on physical properties. Uses of solvation scales in mechanistic studies.Basic	12

	concept of solvent isotope effect.	
IV	**Catalysis** Specific and general catalysis, Acid-base catalysis: General methods of investigation, Mechanisms, Acidity functions and their use in the elucidation of mechanisms Bronsted catalysis law. Enforced and intramolecular acid-base catalysis.Micellar catalysis.	12
V	**Correlation Analysis** Introduction, simple and multiple linear regression, correlation coefficient, t - test, F- test. Criteria of goodness of fit. The relative importance of different effects as indicated by multiple regression. Applications of correlation analysis in understanding reaction mechanisms.	12
References	• Kinetics and Mechanisms of Chemical Transformations, J. Rajaram, J.C. Kuriacose, MacMillan India Ltd.,1998. • Physical Organic Chemistry, C.D. Ritchise, Marcel Dekker Inc., New York,1990. • Physical Organic Chemistry, N.S. Isaacs, Longmann,1998. • Correlation Analysis of Organic Reactivity, J.Shorter, Research Studies Press,Chichester, 1998. • An introduction to Physical Organic Chemistry, E.M.Kosower,JohnWiley&Sons,NewYork, 1968.	
Course Outcomes	At the end of the course, students will be able to: ➢ Spell out the principles of kinetics. ➢ Identify the solvent effect on reaction rates. ➢ Explain the principle and practice of catalysis. ➢ Describe the basics of correlation analysis and apply it for the reaction mechanism	
References	Text Books (with chapter number & page number, wherever needed): 1. 2.	

	Reference Books: 1. 2.		
	E-Resources 1. 2.		
Course Outcomes	After successful completion of the course students will be able to ➢ ***Spell out the principles of kinetics.*** ➢ ***Identify the solvent effect on reaction rates.*** ➢ ***Explain the principle and practice of catalysis.*** ➢ ***Describe the basics of correlation analysis and apply it for the reaction mechanism***		
Semester	III	Course Code	21CHEP03D3
Course Title	MEDICINAL CHEMISTRY		
No. of Credits	4	No. of contact hours per week	4
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Core Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to enable students to understand drug actions and to learn chemistry of various types of drugs such as antibiotics, analgesics, antipyretics, cardiovascular,anti-tubercular drugs, antihistamines and antimalarials.		
UNIT	Content		No. of Hours
I	**Drug action and sulpha drugs** Physiochemical properties in relation to biological action - influence of route of administration. Biotransformation-absorption from stomach -absorption from intestines -sites of loss - metabolism and excretion, harmful drugs and their side effects. Sulpha drugs - sulphathiazole, sulphamerazine, sulphaguanidine and other sulpha drugs, -synthesis, mechanism of action –uses.		12
II	**Antibiotics** Antibiotics -A study of Chloramphenicol, Penicillin - semisynthetic Penicillin -gross structural features Streptomycin-Cephalasporin and Tetracycline. Polyene antifungal antibiotics-nystatin, fusicidic acid-		12

	griesofulvin. (gross structural features not needed).	
III	**Analgesics and antipyretics** Study of morphine -structure activity relationship (SAR)-morphine analogues-Codeine -synthetic analgesics- pethidines and methadones -narcotic antagonist. Antipyreticanalgesics - salicylic acid, pyrazole and para amino phenol derivatives. Sedatives:Barbiturates, Benzodiazepines.	12
IV	**Cardio Vascular and anti-tubercular drugs** Cardiovascular Drugs -classification, cardiac glysocides, anti-hypertensive and hypotensive agents -mode of action –anti-arythamic agents. Anti -tubercular drugs - sulphanamides -sulphones, p-amino salicylic acid -INH - ethambutal, Rifampicin	12
V	**Drug Development and Regulatory Affairs** Drug Discovery and Preclinical Testing - stages of drug discovery- identification and optimization. Explore preclinical testing methodologies - in vitro and in vivo studies - assessing drug safety and efficacy. Clinical Trials: Study the phases of clinical trials (I, II, III) - drug approval by regulatory agencies. Understand the design of clinical trials – endpoints - statistical considerations - ethical issues. Regulatory Standards and Ethics: Overview of regulatory frameworks and standards (e.g., FDA, EMA) - drug development and approval. Discuss ethical considerations in clinical research, - protection of human subjects.	12
References	• Medicinal Chemistry Vol - I and II, A. Burger, Wiley inter Science, NewYork,1990. • Text book of organic, Medicinal and Pharmaceutical Chemistry, O. Wilson, O. Giswoldand • F. George, Lippincott Company, Philadelphia, 9thEdn., 1991. • Text book of Pharmaceutical Chemistry, Bentley and Driver.	

Course Outcomes	At the end of the course, students will be able to: ➢ *Outline the physicochemical properties of drugs.* ➢ *Describe drug absorption, distribution, metabolism and excretion.* ➢ *Formulate the synthesis of few important drugs such as analgesics, antipyretics, cardiovascular, anti-tubercular drugs, antihistamines and antimalarials.* ➢ *Evaluate and Implement drug development processes, including preclinical testing, clinical trials, and regulatory standards, and apply knowledge to ensure compliance and address ethical considerations in drug development.*
References	Text Books (with chapter number & page number, wherever needed): 1. 2.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	After successful completion of the course students will be able to ➢ ***Outline the physicochemical properties of drugs.*** ➢ ***Describe drug absorption, distribution, metabolism and excretion.*** ➢ ***Formulate the synthesis of few important drugs such as analgesics, antipyretics, cardiovascular, anti-tubercular drugs, antihistamines and antimalarials.*** ➢ ***Evaluate and Implement drug development processes, including preclinical testing, clinical trials, and regulatory standards, and apply knowledge to ensure compliance and address ethical considerations in drug development.***

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (3)	✓ (1)	✓ (2)	✓ (1)	✓ (1)
CO2	✓ (2)	✓ (2)	✓ (2)	✓ (1)	✓ (2)
CO3	✓ (1)	✓ (1)	✓ (1)	✓ (3)	✓ (2)
CO4	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (3)

Semester	IV	Course Code	21CHEP03D4
Course Title	ENVIRONMENTAL CHEMISTRY		
No.of Credits	4	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Modular Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to provide an overview of water, air, soil, radioactive and noise pollution including methods for prevention of pollution and its control measures.		

UNIT	Content	No. of Hours
I	**Water Pollution** Types of water pollution, ground water and surface water pollution - Sources and harmful effects-sources and effects of major water pollutants-Inorganic pollutants and toxic metals-Oxygen demanding wastes-Organic pollutants-Plant nutrients-detergents-suspended matter-radioactive wastes-Sediments-Thermal pollutants –oilspills – oilspill removal methods- disease causing agents	4 Hours
II	**Air Pollution** Atmosphere-structure-functions and photochemical reactions-sources of air pollution- Natural and manmade-classification and effects of air pollutants -CO, CO2, SO2, SO3,NO and NO2- hydrocarbon as pollutant-reactions of hydrocarbons and effects - particulate pollutants- sources and effects of organic and Inorganic particulates - Green house effect -impact on global climate-control measures-role of CFC's -ozone holes-effects of ozone depletion-smog- components of	6 Hours

	photochemical smog-effects of photochemical smog.	
III	**Pesticides and Soil Pollution** Pesticides-classification, mode of action-toxic effects of chlorinated hydrocarbons, organophosphorous compounds and carbamates-alternatives to chemical pesticides- (pheromones, Juvenile harmones, chemosterilization)-Soil pollutants-sources and effects of industrial wastes-urban wastes-radioactive pollutants-agricultural wastes-solid waste management in cities, soil pollution control measures	4 Hours
IV	**Analysis and Control** Sampling of polluted water-preservation-main quality characteristics of water-alkalinity, hardness, total solids- TDS - DO, BOD, COD, TOC, fluoride and chloride. Defluoridation techniques-Iron removal-sampling of gaseous pollutants and particulates –adsorption - absorption - scrubbing – cold trapping – filtration - cyclone separator - gravity settling - electrostatic precipitators - thermal precipitators - analysis of CO by gas chromatography, NO by chemiluminescence and SO2 by spectrophotometer..	4 Hours
V	**Green Chemistry and Sustainable Practices** Principles of Green Chemistry: Study of the twelve principles of green chemistry and their application to minimize environmental impact. Focus on designing safer chemicals and processes. Sustainable Environmental Practices: Exploration of sustainable practices in environmental management, including waste reduction, resource efficiency, and life cycle assessment.	6 Hours
References		
Course Outcomes	➢ *Explain the cause, consequence and cure of various types of pollution.* ➢ *Identify the effect of metals and metallic compounds on human health.* ➢ *Assess the implication of climate change.* ➢ *Describe the methods analyze and control air and water pollution.* ➢ *Implement and Promote principles of green chemistry and sustainable practices in environmental management, including waste reduction, resource efficiency, and life cycle assessment, and explore emerging trends and technologies in environmental sustainability.*	

References	1. Environmental Chemistry, A.K. De, Wiley Eastern Ltd, 3rd Edn.,1994. 2. Environmental Chemistry, B.K. Sharma, Goel Publishers,2001. 3. Environmental Chemistry, M.S. Sethi, Sri Sai Printographers,1994. 4. Text book of Environmental Chemistry, C.D. Tyagi and M.Mehra, Anmol Publishers, 1996. 5. Fundamentals of Environmental Pollution, K. Kannan, S. Chand & Co.,1997.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	On completion of the course, students should be able to do ➢ ***Explain the cause, consequence and cure of various types of pollution.*** ➢ ***Identify the effect of metals and metallic compounds on human health.*** ➢ ***Assess the implication of climate change.*** ➢ ***Describe the methods analyze and control air and water pollution.*** ➢ ***Implement and Promote principles of green chemistry and sustainable practices in environmental management, including waste reduction, resource efficiency, and life cycle assessment, and explore emerging trends and technologies in environmental sustainability.***

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (3)	✓ (1)	✓ (1)	✓ (1)	✓ (1)
CO2	✓ (2)	✓ (1)	✓ (2)	✓ (1)	✓ (1)
CO3	✓ (3)	✓ (3)	✓ (2)	✓ (1)	✓ (1)
CO4	✓ (3)	✓ (1)	✓ (3)	✓ (1)	✓ (1)
CO5	✓ (3)	✓ (2)	✓ (3)	✓ (2)	✓ (1)

Semester	IV	Course Code	21CHEP03D6
Course Title	ADVANCED METHODS IN ORGANIC SYNTHESIS		
No.of Credits	4	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Modular Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to understand basics of asymmetric synthesis, to know the chemistry of various oxidizing and reducing agents, to understand the reaction and mechanism of selected name reactions, the chemistry of protecting and deprotecting groups and to know the synthesis of selected drug molecules.		
UNIT	Content		No. of Hours
I	**Asymmetric Synthesis** Basic principles of Asymmetric synthesis – Definition - Stereospecific, Stereoselective enanatioselective and diastereoselective- Asymmetric synthesis on chiral substrate: Nucleophilic addition to α–chiral carbonyl compounds; Asymmetric synthesis using chiral reagents: Chiral modification of lithium aluminum hydride, BINAL-H - application in reduction of prochiral ketones T. S model; oxazaborolidines. T.S model; Asymmetric Michael addition to α ,β – unsaturated carbonyl compounds T.S model; Asymmetric synthesis using chiral auxiliary: menthol, oxazolidine-2-one, and BINOL; Asymmetric synthesis using chiral catalysts: Sharpless epoxidation. Resolutions via diastereomeric salt formation- Commonly used resolving agents- (S)-phenylethylamine, L-tartaric acid, Resolution of chiral ligands - BINOL, trans1,2-diaminocyclohexane.		4 Hours
II	**Oxidation and Reduction reactions** Oxidation : Structure and Mechanism of reactions involving oxidation with PCC, PDC, Swern oxidation, TBHP, DIAD, IBX, Dess-Martine periodinane, TEMPO. Reduction : Structure and Mechanism of reactions involving reduction with BH3:THF, Catecholborane, Na(CN)BH3 , Raney nickel, Zn in acidic media, Lindlar catalyst, Al(OiPr)3, Rosenmund Reduction.		6 Hours
III	**Name reactions** Reaction and Mechanism of following name reaction: Arndt-Eistert Syntheis, Buchwald-Hartwig Cross Coupling Reaction, Grubbs reaction, Heck reaction, Suzuki Coupling,		4 Hours

	Lawesson's Reagent, Mukaiyama Aldol Addition, Sandmeyer Reaction, Stille Coupling, Tebbe Olefination, Yamaguchi Esterification and Robinsonannulations.	
IV	**Functional Group interconversion by substitution including protection and deprotection** Conversion of Alcohols to Alkylating Agents-Sulfonate Esters, Halides-Introduction of Functional Groups by Nucleophilic Substitution at Saturated Carbon-Nitriles, Oxygen Nucleophiles, Nitrogen Nucleophiles, Sulfur Nucleophiles, Phosphorus Nucleophiles- Interconversion of Carboxylic Acid Derivatives-Acylation of Alcohols, Preparation of Amides- Installation and removal of protective groups-hydroxy protecting groups-Ether-Bn, Tr and PMB-MOM, THP-Silyl-TMS-Cl, TBDMS, TIPS-Cl-Esters-acetic anhydride, benzoyl chloride-Amino-Protecting Groups-Boc, CBz, Bn, Allyl, Phthalyl-Carbonyl-Protecting Groups-1,3- Dioxanes, 1,3-dithianes	4 Hours
V	**Synthesis of Drug molecules** Metabolic drug-Diabetics- Type-1 and Type-2 diabetics-Synthesis of sitaglyptin, Linaglyptin, Saxaglyptin.Proton pump Inhibitors-Synthesis of omeprazole, lansoprazole, pantoprazole. Sulphadrugs –Synthesis of sulphathiazole, sulphamerazine, sulphaguanidine	6 Hours
References		
Course Outcomes	➢ *Describe the methods of asymmetric synthesis which involve chiral substrate, chiral reagents, chiral auxiliary and chiral catalyst.* ➢ *Predict the structure and mechanism of reactions involving selected oxidizing and reducing agents.* ➢ *Identify the mechanism of selected name reactions.* ➢ *Analyze the chemistry of protection and de-protection strategies involved in hydroxyl group by ether and ester, carbonyl group, and amino group sand functional group interconversion by substitution reactions.*	
References	6. StereochemistryofOrganicCompounds,E.L.Eliel,SamuelH.Wilen,Wiley –IndiaEdition2008. 7. AdvancedOrganicChemistryPartA,F.A.CareyandR.J.Sundberg,Springer,5th Edn.,2007. 8. AdvancedOrganicChemistryPartB,F.A.CareyandR.J.Sundberg,Springer,5th Edn.,2007. 9. Advanced Organic Chemistry Reactions,	

	Mechanisms and Structure, M. B. Smith and J.March, Wiley, 6th Edn., 2007. 10. AGuidebooktoMechanisminOrganicChemistry ,P.Sykes,OrientLongman,6th Edn.,1988. 11. Organic Chemistry, I.L. Finar, Vol. II, ELBS, 5th Edn.,1974. 12. ModernMethodsofOrganicSynthesis,Carruther s,W.andColdham,I,CambridgeUniversity Press, UK, 4th Edn.,2004. 13. Organic Synthesis, Michael B Smith, 3rd Edn., Academic Press,2011. 14. ProtectiveGroupsinOrganicSynthesis,Theodora W.GreeneandPeterG.M.Wuts,3rd Edn., John Wiley & Sons, Inc.1999. 15. Mathad,V.T.;Govindan,S.;Kolla,N.K.;Maddipa tla,M.;Sajja,E.;Sundaram,V.;Organic Process Research & Development 2004, 8,266-270. 16. Ahn, K-H.; Kim, H.; Kim, J. R.; Jeong, S. C.; Kang, T. S.; Shin, H. T.; Lim, G. J. Bull. Korean Chem. Soc. 2002, 23,626. 17. 12. Desai, A. A. Angew. Chem. Int. Ed. 2011, 50, 1974 – 1976.
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	On completion of the course, students should be able to do ➢ ***Describe the methods of asymmetric synthesis which involve chiral substrate, chiral reagents, chiral auxiliary and chiral catalyst.*** ➢ ***Predict the structure and mechanism of reactions involving selected oxidizing and reducing agents.*** ➢ ***Identify the mechanism of selected name reactions.*** ➢ ***Analyze the chemistry of protection and de-protection strategies involved in hydroxyl group by ether and ester, carbonyl group, and amino group sand functional group interconversion by substitution reactions.***

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (3)	✓ (1)	✓ (2)	✓ (1)	✓ (1)
CO2	✓ (2)	✓ (2)	✓ (2)	✓ (1)	✓ (2)
CO3	✓ (1)	✓ (1)	✓ (1)	✓ (3)	✓ (2)
CO4	✓ (3)	✓ (3)	✓ (2)	✓ (2)	✓ (3)

Semester	IV	Course Code	21CHEP04M3
Course Title	GREEN METHODS IN CHEMISTRY		
No.of Credits	4	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Modular Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to understand the basics of green chemistry, types of environmental friendly organic reactions and to have an idea about the need of green chemistry.		
UNIT	Content		No. of Hours
I	**Introduction to green chemistry** What is Green Chemistry? -Need for Green Chemistry-Goals of Green Chemistry-Advantages-Limitations/Obstacles in the pursuit of the goals of Green Chemistry--Basic principles of Green Chemistry-Atom-economy-Rearrangement reactions-Claisen and Fries- Addition reaction-Addition of HBr to alkene-Michel addition-Diels-Alder reaction-reducing toxicity-green solvents.		4 Hours
II	**Microwave Assisted organic synthesis (MAOS)** Microwave activation – advantage of microwave exposure – specific effects of microwave-Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzamide, methylbenzoate to benzoic acid), Oxidation (of toluene, alcohols)-Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Diels-		6 Hours

	Alder Reaction, Decarboxylation-Microwave assisted solid state reactions: Deacetylation, Deprotection, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; benzimidazoles.	
III	**Ionic liquids and PTC** Introduction – synthesis of ionic liquids – physical properties – applications in alkylation - hydroformylations– epoxidations – synthesis of ethers – Friedel-craft reactions – Diels-Alder reactions – Knoevengal condensations – Wittig reactions – Phase transfer catalyst - Synthesis – applications of Quaternary ammoniumsalts.	4 Hours
IV	**Ultrasound Assisted organic synthesis (UAOS)** Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.	4 Hours
V	**Organic Reactions in Aqueous media** Organic reactions in water: Acid catalyst (Lewis acid catalyst)-Metal mediated C-C bond formation-(Allylation, Benzylation and Arylation of carbonyl compounds, Aldol, Pinacol coupling-Conjugate addition -1,3-dipolar reactions-triazole and tetrazole ring formation- Reduction of epoxides and halides-Hydroxylation,Bayer-villigeroxidation).	6 Hours
References		
Course Outcomes	➢ *Explain the importance of green chemistry* ➢ *Demonstrate the basic principles of green chemistry* ➢ *Examine the general difference between the ordinary type of reactions and green chemistry*	
References	1. Green Chemistry-An Introductory Text; Mike Lancater; RSC publishers2011. 2. Anastas, P.T. & Warner, J.K. *Green Chemistry-Theory and Practical*, Oxford University Press(1998). 3. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005). 4. Green Chemistry – Environmentally benign reactions – V. K. Ahluwalia. Ane Books India (Publisher).(2006). 5. Green Chemistry – Designing Chemistry for the Environment – edited by Paul T. Anastas& Tracy C. Williamson. Second	

	Edition,(1998). 6. Green Chemistry – Environment friendly alternatives- edited by RashmiSanghi&M. M. Srivastava, Narora Publishing House, (2003). 7. Organic Reactions in Water: Principles,Strategies and Applications-U. M. Lindstrom; Blackwell Publishing Ltd(2007)
	Reference Books: 1. 2.
	E-Resources 1. 2.
Course Outcomes	On completion of the course, students should be able to do ➢ ***Explain the importance of green chemistry*** ➢ ***Demonstrate the basic principles of green chemistry*** ➢ ***Examine the general difference between the ordinary type of reactions and green chemistry***

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (1)		✓ (1)	✓ (2)	
CO2	✓ (3)		✓ (1)		✓ (1)
CO3	✓ (2)	✓ (1)	✓ (1)	✓ (1)	

Semester	II	Course Code	21CHEP02G1
Course Title	ELEMENTS OF BIOCHEMISTRY		
No.of Credits	4	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Modular Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to provide a comprehensive introduction to biochemistry and to learn the chemistry of enzymes, structures of nucleic acids and biosynthesis of proteins.		
UNIT	Content		No. of Hours

I	**Enzymes** Factors affecting enzyme activity (temperature, pH, substrate concentration, enzyme concentration) active site, enzyme - substrate complex, allosteric interaction, enzyme inhibition, uses of enzymeinhibitors.	4 Hours
II	**Enzyme technology and Enzyme immobilization** Use of enzymes, selection of sources of enzymes, enzyme extraction (abrasives, liquid shear, osmotic shock, alkali, detergents, organic solvents, sonication) enzyme purification (removal of nucleic acids, removal of solids, purification and concentration, precipitation, adsorption, phase separation, column chromatography, electrophoresis, dialysis). Methods of immobilization of enzymes (adsorption, covalent bonding, cross linking; entrapment, encapasulation), applications of immobilized enzyme systems, effect of immobilization on Km, V max, the effect of pH and the effect of inhibitors.	6 Hours
III	**DNA and RNA** Double helical structure of DNA, structure of RNA, DNA replication, semi-conservative nature of replication, RNA transcription, Genetic code and biosynthesis of proteins.	4 Hours
IV	**Recombinant DNA** Cloning vectors - restriction enzymes for cloning - techniques of restriction mapping, construction of a restriction map - construction of chimeric DNA, molecular probes, construction and screening of genomic and CDNA libraries.	4 Hours
V	**Metabolism and Bioenergetics** Metabolic Pathways: Overview of major metabolic pathways - citric acid cycle - oxidative phosphorylation - electron transport chain - energy production and utilization. Bioenergetics - principles of bioenergetics, including ATP synthesis, energy transfer, and thermodynamics of biochemical reactions. Role of coenzymes and cofactors. Examination of the integration and regulation of metabolic pathways - fed and fasting states - response to hormonal signals.	6 Hours
References		
Course Outcomes	➢ *Predict the sources, extraction and purification of enzymes.* ➢ *Describe the uses of immobilized enzymes.*	

	➢ *Analyze the double helical structure of DNA and its replication.* ➢ *Evaluate the structure of RNA and its transcription* ➢ *Integrate and Apply principles of metabolism and bioenergetics to understand energy production and utilization in biochemical processes, and analyze the regulation of metabolic pathways in different physiological states.*	
References	1. Biotechnology, M.D. Travan, S. Boffev, Tata McGraw Hill, 1st Edn.,1987. 2. Elements of Biotechnology, P.K. Gupta, Rastogi Publications, 1stEdn.,1994. 3. Biotechnology, K. Trehan, Wiley Eastern Ltd., 1stEdn.,1990. 4. Biochemistry, S.C. Rastogi, Tata Mc.Graw Hill, 1st Edn.,1993. 5. Outlines of Biochemistry, E.E. Conn, P.K. Stumpf, Wiley Eastern Ltd., 4th Edn.,1976.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	On completion of the course, students should be able to do ➢ ***Predict the sources, extraction and purification of enzymes.*** ➢ ***Describe the uses of immobilized enzymes.*** ➢ ***Analyze the double helical structure of DNA and its replication.*** ➢ ***Evaluate the structure of RNA and its transcription*** ➢ ***Integrate and Apply principles of metabolism and bioenergetics to understand energy production and utilization in biochemical processes, and analyze the regulation of metabolic pathways in different physiological states.***	

Mapping of COs with PSO

PSO / CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓ (3)	✓ (2)	✓ (2)		
CO2	✓ (2)			✓ (2)	
CO3		✓ (2)			
CO4	✓ (2)		✓ (2)	✓ (2)	✓ (2)
CO5	✓ (2)		✓ (2)	✓ (2)	✓ (2)

Semester	IV	Course Code	**21CHEP04M2**
Course Title	**WATER QUALITY MONITORING, MANAGEMENT AND TREATMENT**		
No.of Credits	2	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Modular Course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	The objective of the course is to given an in-depth understanding of ground water and surface water pollution and its control measures. In addition, the students will also learn the water treatment methods, water analysis methods, sewage and industrial effluent treatment methods and water resource management.		
UNIT	Content		No. of Hours
I	**Water quality parameters and their determination** Physical, chemical and biological standards significance of these contaminants over the quality and their determinations - Electrical conductivity - turbidity - pH, total solids, TDS - alkalinity - hardness - chlorides - DO - BOD-COD - TOC - nitrate –sulphate-- arsenic - mercury - biomass and chlorophyll estimation - estimation of MPN – bioassay.		4 Hours
II	**Water pollution Sources and control measures** Surface and ground water pollution - Harmful effects-pollution of major rivers - protecting ground water from pollution - ground water pollution due to Fluoride, Iron, Chromium and Arsenic sources, ill effects and treatment methods. Water pollution control- stabilization of the ecosystem – waste treatment reclamation - various approaches to prevent and control water pollution.		6 Hours
III	**Water treatment methods** Treatment for community supply - screening, sedimentation, coagulation, filtration - removal of micro organisms - chlorination, adding bleaching powder, UV irradiation and ozonation. Demineralization of water for industrial purposes - boiler problems - scale and sludge formation - prevention of scale formation-internal and external treatment –Demineralization - zeolite process.		4 Hours

IV	**Sewage and industrial effluent treatment** Sewage - characteristics - purpose of sewage treatment - methods of sewage treatment - primary - secondary and tertiary - Role of algae in sewage treatment. Types of industrial wastes - treatment of effluents with organic and inorganic impurities - treatment of waste waters from specific industries - pulp and paper - chemical industry - food processing-water hyacinth in the treatment of industrialeffluents.	4 Hours
V	**Water Management** Water resources management - rain water harvesting methods - percolation ponds - check darns - roof top collection methods - water management in industries - recycling and reuse of waste water - metal recovery from metal bearing waste water - recovery of zinc and nickel.	6 Hours
References		
Course Outcomes	➢ *Analyze polluted water samples.* ➢ *Evaluate pollutants and their effect on environment and human health Suggest water treatment methods for domestic and industrial purposes.* ➢ *Describe the principles and design suitable water treatment processes, including sedimentation, coagulation, chlorination and ozonation as well as sewage and industrial effluent treatment.*	
References	1. Chemical and Biological Methods for Water Pollution Studies, R.K. Trivedy andP.K. Goel, Environmental Publications,1986. 2. Engineering Chemistry, P.C. Jain and Monica Jain, Dhanpat Rai & Sons,1993. 3. Environmental Chemistry, B.K. Sharma, Goel Publishing House,2001. 4. Water Quality and Defluoridation Techniques, Rajiv Gandhi National Drinking Water Mission Publication, 1994.	
	Reference Books: 1. 2.	
	E-Resources 1. 2.	
Course Outcomes	On completion of the course, students should be able to do ➢ *Analyze polluted water samples.* ➢ *Evaluate pollutants and their effect on environment and human health Suggest water treatment methods for domestic and industrial purposes.* ➢ *Describe the principles and design suitable water*	

	treatment processes, including sedimentation, coagulation, chlorination and ozonation as well as sewage and industrial effluent treatment.

Mapping of COs with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓ (1)		✓ (1)	✓ (2)	
CO2	✓ (3)		✓ (1)		✓ (1)
CO3	✓ (2)	✓ (1)	✓ (1)	✓ (1)	

Semester	II	Course Code	**21CHEPO2VS1**
Course Title	**DESIGN THINKING INNOVATION AND PRODUCT DEVELOPMENT**		
No.of Credits	2	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Value added course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	➢ *Study a problem from multiple perspectives* ➢ *Learn how to frame the design challenge properly* ➢ *Learn how to ideate, prototype and Iterate solutions.* ➢ *Learn from the overall design process how to create value as entrepreneurs* ➢ *Learn how to design successful products or enterprises.* .		
UNIT	Content		No. of Hours
I	Design *vs.* Design thinking; Design thinking: Understanding the Mindsets- Empathy, Optimism, Embrace Ambiguity, Make it, Learn from Failure, Iterate, Create Confidence, Creativity Convergent & Divergent Thinking. The 5 stages of the Design Thinking process- Empathize, Define (the problem), Ideate,		4 Hours

	Prototype, and Test.	
II	Ideation tools & exercises. Sample Design Challenge, Introduction to the Design Challenge- Themes, Storytelling and Tools for Innovation. Empathize-Understand customers, Empathy Maps, Empathize-step into customers shoes-Customer Journey Maps, Define – Analysis & Drawing Inferences from Research.	6 Hours
III	The Design Challenge: Define the Design Challenge, Prototyping & Iteration-Feasibility Study, Testing-Documentation and the Pitch.	4 Hours
IV	Entrepreneur – Scope; Popular Women Entrepreneurs, Institutional support for entrepreneurs, Start-ups – Development Phases, Preparation of project report, Entrepreneurship *vs.* Startups, SME's *vs*. Scaleups. Opportunities for Startups in India.	4 Hours
V	IPR- Genesis and Development, Basic Concepts and Need, Nature- Patents-Patent search, Patent filing, Copyrights, Geographical Indications, trademark, Industrial design; Pros and cons of IPR.	6 Hours
References		
Course Outcomes	➢ .	
References	1. Transforming an Idea into a Business with Design Thinking, Mashhood Alam, Routledge, Taylor& Francis Group, USA and UK, 2019 2. Design Thinking, Gavin Ambrose, Paul Harris, AVA Book Production Pvt. Limited.; Singapore, 2010 3. Entrepreneurship & Innovation: Global insights from 24 leaders, James C. Barrood, Rothman Institute of Entrepreneurship, Farleigh Dickinson University, US, 2010 4. Intellectual Property, Siva Vaidhyanathan, Oxford University Press, USA, 2017. 5. Entrepreneurial Development, Jayashree Suresh, Margham Publications , Chennai, 2017.	
	Reference Books: 1. 2.	

Semester	II	Course Code	**21CHEPO2VS2**
Course Title	Computing Tools In Chemistry		
No.of Credits	2	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Value added course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	**Objectives:** The objective of the course is to learn open source drawing and molecular visualization tools which are necessary for chemists. .		
UNIT	Content		No. of Hours
I	**Drawing tools in chemistry** Free open-source drawing tools in chemistry: Drawing rings and chains– editing - manipulating the structure – converting to 3D structures – optimizing the structures – graphics		4 Hours
II	**3D molecular visualization tools** Avogadro: Draw – manipulate – measurement of bond angle, bond length – rotation of bonds - Energy minimization – Conformations – visualizing proteins - Animation and graphics		6 Hours
III	**Mercury 3.8 (CCDC)** Analyzing single crystal X-ray crystallographic data – measurement of bond angle, bond length and dihedral angle - simulating powder XRD data from single crystal X-ray data – generating graphics – visualizing protein structures		4 Hours
IV	NMR software Processing ^{1}H NMR and ^{13}C NMR spectra;		4 Hours

	Integration; peak picking; stacking; interpretation of 2D NMR data – COSY – NOESY.	
V	Graphing tools Graphing tools used in chemistry – plotting graphs – curve fitting analysis – exporting data and graphs – creating graphics	6 Hours
References		
Course Outcomes	➢ . *Draw molecular structures* ➢ *Convert 2D molecular structures to 3D structure and perform structure optimization* ➢ *Visualize molecules and create animations* ➢ *Analyze single crystal X-ray crystallographic structure and generate images* ➢ *Interpret 1D and 2D NMR spectral data* ➢	
References	6. Transforming an Idea into a Business with Design Thinking, Mashhood Alam, Routledge, Taylor& Francis Group, USA and UK, 2019 7. Design Thinking, Gavin Ambrose, Paul Harris, AVA Book Production Pvt. Limited.; Singapore, 2010 8. Entrepreneurship & Innovation: Global insights from 24 leaders, James C. Barrood, Rothman Institute of Entrepreneurship, Farleigh Dickinson University, US, 2010 9. Intellectual Property, Siva Vaidhyanathan, Oxford University Press, USA, 2017. 10. Entrepreneurial Development, Jayashree Suresh, Margham Publications , Chennai, 2017.	
	Reference Books: 1. 2.	
	E-Resources 1. 1. https://courseupload.net/chemdraw-professional-maste200321/ 2. http://avogadro.cc/ 3. https://www.ccdc.cam.ac.uk/solutions/csd-	

	core/components/mercury/ 4. https://mestrelab.com/download/mnova/ 5. https://www.bruker.com/en/products-and-solutions/mr/nmr-software/topspin.html 2.
Course Outcomes	On completion of the course, students should be able to do ➢ *Draw molecular structures* ➢ *Convert 2D molecular structures to 3D structure and perform structure optimization* ➢ *Visualize molecules and create animations* ➢ *Analyze single crystal X-ray crystallographic structure and generate images* ➢ *Interpret 1D and 2D NMR spectral data*

Semester	II	Course Code	21CHEPO2VS3
Course Title	Materials For Biological Applications		
No.of Credits	2	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Value added course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	This course is designed to understand the requirements and to gain insight in to the applications of materials for biological applications..		
UNIT	Content		No. of Hours
I	Design and Preparation of Bio mimetic and Bio inspired Materials Biocompatibility of materials – materials of biological origin – synthetic materials – surface modification of materials for specific		4 Hours

	applications - biosorption.	
II	Drug Delivery Types of drug carries - Lipid-based systems - Peptide-based systems -Glycan-based systems -Nucleic acid-based systems – Dendrimer - based systems	6 Hours
III	Bone Regeneration Injectable hydrogels as bone regeneration material - Ceramics -Synthetic bone substitute. Wound healing Therapeutic protein - Growth factor.	4 Hours
IV	**Smart Devices** Sensor – Sensing principles - Transducer - Electronic tongues and aptasensors Electrochemical sensor arrays - Electronic tongue – Aptasensors – Potentiometry Voltammetry – Biomarkers - Biomedical applications - Pharmaceutical applications. Smart devices - Smart stent – Optrodes. Organ-on-chip. Microfluidics – On-chip integration – Detection-Diagnosis.	4 Hours
V	Nucleic Acid Delivery Gene delivery - Nonviral vectors - Lipid-based vector - Polymer-based vector - siRNA-conjugates. Artificial virus particles Virus-like particles - Viral nanoparticles – Bacteriophages - Genetic engineering - Chemical modifications - Biomedical applications.	6 Hours
References		
Course Outcomes	➢ *. Predict the basic requirements of materials for biological applications* ➢ *Identify materials for drug and nucleic acid delivery.* ➢ *Understand the concepts behind smart sensor fabrication.* ➢	
References	11. Transforming an Idea into a Business with Design Thinking, Mashhood Alam, Routledge, Taylor& Francis Group, USA and UK, 2019 12. Design Thinking, Gavin Ambrose, Paul Harris, AVA Book Production Pvt. Limited.; Singapore, 2010 13. Entrepreneurship & Innovation: Global insights from 24 leaders, James C. Barrood, Rothman Institute of Entrepreneurship, Farleigh Dickinson University, US, 2010	

	14. Intellectual Property, Siva Vaidhyanathan, Oxford University Press, USA, 2017. 15. Entrepreneurial Development, Jayashree Suresh, Margham Publications , Chennai, 2017.
	Reference Books: *1.* Biological Materials Science: Biological Materials, Bioinspired Materials, and Biomaterials, by **M. A. Meyers and P-Y. Chen,** Cambridge University Press, 1st ed. 2014. *2.* Engineered Carbohydrate-Based Materials for Biomedical Applications: Polymers, Surfaces, Dendrimers, Nanoparticles, and Hydrogels by R. Narain, John Wiley & Sons,
	E-Resources .
Course Outcomes	On completion of the course, students should be able to do ➢ *Predict the basic requirements of materials for biological applications* ➢ *Identify materials for drug and nucleic acid delivery.* ➢ *Understand the concepts behind smart sensor fabrication.*

Semester	II	Course Code	**21CHEP04VS4**
Course Title	HUMAN VALUES AND PROFESSIONAL ETHICS		
No.of Credits	2	No. of contact hours per week	2 Hours
New Course/Revised Course	Revised Course	If revised, Percentage of Revision effected	20%
Category	Value added course		
Scope of the Course (may be more than one)	Basic Skill		
Cognitive Levels addressed by the course	K-1: K-2: Understand K-3: K-4: K-5: K-6:		
Course Objectives (Maximum.5)	This course is designed to understand the human values, ethics, quality control to understand the ethical responsibilities...		
UNIT	Content		No. of Hours

I	**Human Values** Objectives, Morals, Values, Ethics, Integrity, Work Ethics, Service Learning, Virtues, Respect For Others, Living Peacefully, Caring Sharing, Honesty, Courage, Valuing time, Co-Operation, Commitment, Empathy, Self - Confidence, Challenges in the workplace, Spirituality.	4 Hours
II	**Safety, Responsibility and Rights** Safety definition, Safety and Risk, Risk analysis, Assessment of safety and risks, Safe exit, Risk benefit analysis, Safety lesson from challenges, Collective bargaining, Confidentiality, Conflict of interest, Occupational crime, Human rights, Employee rights, Whistle Blowing, Intellectual property rights.	6 Hours
III	. **Introduction to GMPs** Quality assurance and related concepts, GMP - a concept, Sanitation and hygiene, Quantification and validations, Complains, Products recalls, Contract production and analysis, Self-inspection, Quality audits, Supplier audits and approvals, Training, personal hygiene,	4 Hours

	Equipments, materials and documentations.	
IV	**Practice of GMPs** Good practice in production, Good practice in quality control, Good manufacturing practice for APIs (Bulk drug substances), Supporting and supplementary guidelines for sterile products. .	4 Hours
V	**Values and Science** Introduction, Scientists responsibility, scientific responsibility, Ethical responsibility, inadequate behavior of scientists, Ethical valuation, The need of ethics in scientific activity	6 Hours
References		
Course Outcomes	➢ . *Understand the significance of human values.* ➢ *To Understand the safety responsibilities of occupation.* ➢ *To Know the good practice of manufacturing in pharma industries.* ➢ *To Understand the values and science in ethics.* ➢	

References	Reference Books: 1) R.S Naagarazan, A text book on personal ethics and human values, New Age International Publishers, New Delhi. 2) P.P Sharma, How to practice GMPs, 7th Edition, Vandana Publications, New Delhi. 3) J.A.V Matas, Values and Science: An Analysis for The Ethics In Science - A Review Article, Sociology International Journal, **2018**, *2*, 257 - 265.
	E-Resources .
Course Outcomes	On completion of the course, students should be able to do ➢ *Understand the significance of human values.* ➢ *To Understand the safety responsibilities of occupation.* ➢ *To Know the good practice of manufacturing in pharma industries.* ➢ *To Understand the values and science in ethics.*