



**VIT<sup>®</sup>**

**Vellore Institute of Technology**

(Deemed to be University under section 3 of UGC Act, 1956)

**SCHOOL OF ADVANCED SCIENCES  
DEPARTMENT OF CHEMISTRY**

**M.Sc Chemistry  
(MSH)**

**Curriculum & Syllabi  
(2025-2026 Admitted students)**



## VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

## MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- ❖ **World class Education:** Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- ❖ **Cutting edge Research:** An innovation ecosystem to extend knowledge and solve critical problems.
- ❖ **Impactful People:** Happy, accountable, caring and effective workforce and students.
- ❖ **Rewarding Co-creations:** Active collaboration with national & international industries & universities for productivity and economic development.
- ❖ **Service to Society:** Service to the region and world through knowledge and compassion.

## VISION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

To be an internationally renowned science school in research and innovation by imparting futuristic education relevant to the society.

## MISSION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

- ❖ To nurture students from India and abroad by providing quality education and training to become scientists, technologists, entrepreneurs and global leaders with ethical values for a sustainable future.
- ❖ To enrich knowledge through innovative research in niche areas.
- ❖ To ignite passion for science and provide solutions for national and global challenges.



## **M.Sc Chemistry**

### **PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)**

1. Graduates will be practitioners and leaders in their chosen field.
2. Graduates will function in their profession with social awareness and responsibility.
3. Graduates will interact with their peers in other disciplines in their work place and society and contribute to the economic growth of the country.
4. Graduates will be successful in pursuing higher studies in their chosen field.
5. Graduates will pursue career paths in teaching or research.



## **M.Sc Chemistry**

### **PROGRAMME OUTCOMES (POs)**

PO\_01: Having a clear understanding of the subject related concepts and of contemporary issues.

PO\_02: Having problem solving ability to address social issues.

PO\_03: Having a clear understanding of professional and ethical responsibility.

PO\_04: Having cross cultural competency exhibited by working in teams.

PO\_05: Having a good working knowledge of communicating in English.



## **M.Sc Chemistry**

### **PROGRAMME SPECIFIC OUTCOMES (PSOs)**

On completion of M.Sc. Chemistry programme, graduates will be able to

PSO1: Apply advanced concepts of organic, analytical, physical and inorganic chemistry to solve complex problems to improve human life.

PSO2: Design experiments, analyze, synthesize and interpret data to provide solutions to different industrial problems by working in the pure, inter and multi-disciplinary areas of chemical sciences.

PSO3: Able to independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document.



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## **M.Sc Chemistry**

### **CREDIT STRUCTURE**

#### **Category-wise Credit distribution**

<b>S. No.</b>	<b>Description</b>	<b>Credit</b>	<b>Maximum Credit</b>
1	DC – Discipline Core	<b>28</b>	<b>28</b>
2	DE – Discipline Elective	<b>21</b>	<b>21</b>
3	PI – Projects and Internship	<b>20</b>	<b>20</b>
4	OE – Open Elective	<b>06</b>	<b>06</b>
5	SE – Skill Enhancement	<b>05</b>	<b>05</b>
	<b>Total credits</b>	<b>80</b>	



## M.Sc. Chemistry

### DETAILED CURRICULUM

Discipline Core									
S.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	PCHY501L	Physical Chemistry	Theory Only	1.0	3	1	0	0	4.0
2	PCHY501P	Physical Chemistry Lab-I	Lab Only	1.0	0	0	4	0	2.0
3	PCHY502L	Inorganic Chemistry	Theory Only	1.0	3	1	0	0	4.0
4	PCHY502P	Inorganic Chemistry Lab-I	Lab Only	1.0	0	0	4	0	2.0
5	PCHY503L	Organic Chemistry	Theory Only	1.0	3	1	0	0	4.0
6	PCHY503P	Organic Chemistry Lab-I	Lab Only	1.0	0	0	4	0	2.0
7	PCHY504L	Group Theory and Molecular Spectroscopy	Theory Only	1.0	3	1	0	0	4.0
8	PCHY505L	Organic Synthesis and Methodologies	Theory Only	1.0	3	0	0	0	3.0
9	PCHY506L	Organometallics and Industrial Applications	Theory Only	1.0	3	0	0	0	3.0

Discipline Elective									
S.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	PCHY601L	Analytical Chemistry	Theory Only	1.0	3	0	0	0	3.0
2	PCHY602L	Advanced Organic Chemistry	Theory Only	1.0	3	1	0	0	4.0
3	PCHY603L	Chemistry of Heterocyclic Compounds	Theory Only	1.0	3	0	0	0	3.0
4	PCHY604L	Chemistry of Natural Products	Theory Only	1.0	3	0	0	0	3.0
5	PCHY605L	Photochemistry and Pericyclic Reactions	Theory Only	1.0	4	0	0	0	4.0
6	PCHY606P	Organic Chemistry Lab-II	Lab Only	1.0	0	0	4	0	2.0
7	PCHY607P	Organic Chemistry Lab-III	Lab Only	1.0	0	0	4	0	2.0
8	PCHY608L	Electroanalytical and Separation Techniques	Theory Only	1.0	3	1	0	0	4.0
9	PCHY609L	Environmental and Industrial Analytical Chemistry	Theory Only	1.0	3	1	0	0	4.0
10	PCHY610L	Bioanalytical and Forensic Analysis	Theory Only	1.0	3	0	0	0	3.0
11	PCHY611L	Analytical Quality Assurance for Process Industry	Theory Only	1.0	3	0	0	0	3.0
12	PCHY612P	Analytical / Physical Chemistry Lab-II	Lab Only	1.0	0	0	4	0	2.0
13	PCHY613P	Analytical Chemistry Lab-III	Lab Only	1.0	0	0	4	0	2.0
14	PCHY614L	Advanced Inorganic Chemistry	Theory Only	1.0	3	1	0	0	4.0
15	PCHY615L	Materials Chemistry	Theory Only	1.0	3	0	0	0	3.0
16	PCHY616L	Nanomaterials and Characterization Techniques	Theory Only	1.0	3	0	0	0	3.0
17	PCHY617L	Inorganic Photochemistry	Theory Only	1.0	4	0	0	0	4.0
18	PCHY618P	Inorganic Chemistry Specialization Lab-II	Lab Only	1.0	0	0	4	0	2.0
19	PCHY619P	Inorganic Chemistry Specialization Lab-III	Lab Only	1.0	0	0	4	0	2.0
20	PCHY620L	Process Chemistry in Pharmaceutical Industry	Theory Only	1.0	3	1	0	0	4.0
21	PCHY621L	Pharmacognosy and Phytochemistry	Theory Only	1.0	3	1	0	0	4.0
22	PCHY621P	Pharmacognosy and Phytochemistry Lab	Lab Only	1.0	0	0	4	0	2.0
23	PCHY622L	Pharmaceutical Quality Control and Quality Assurance	Theory Only	1.0	3	0	0	0	3.0
24	PCHY623L	Medicinal Chemistry	Theory Only	1.0	3	0	0	0	3.0
25	PCHY623P	Medicinal Chemistry Lab	Lab Only	1.0	0	0	4	0	2.0
26	PCHY624L	Advanced Physical Chemistry	Theory Only	1.0	3	0	0	0	3.0
27	PCHY625P	General Organic and Inorganic Chemistry Lab	Lab Only	1.0	0	0	4	0	2.0
28	PCHY626P	Analytical Chemistry Practical I	Lab Only	1.0	0	0	4	0	2.0



Projects and Internship									
S.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	PCHY698J	Internship I/ Dissertation I	Project	1.0	0	0	0	0	4.0
2	PCHY699J	Internship II/ Dissertation II	Project	1.0	0	0	0	0	12.0
3	PSET695J	Project Work	Project	1.0	0	0	0	0	4.0

Open Elective									
S.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	PCHY627L	Drug Design	Theory Only	1.0	3	0	0	0	3.0
2	PCHY628L	Polymer Chemistry	Theory Only	1.0	3	0	0	0	3.0
3	PCHY629L	Biophysical Chemistry	Theory Only	1.0	3	0	0	0	3.0
4	PCHY630L	Computational Chemistry	Theory Only	1.0	3	0	0	0	3.0
5	PCHY631L	NMR, EPR and Mass Spectrometry	Theory Only	1.0	3	0	0	0	3.0
6	PCHY632L	Bioorganic Chemistry	Theory Only	1.0	3	0	0	0	3.0
7	PCHY633L	Nanomaterials	Theory Only	1.0	3	0	0	0	3.0
8	PCHY634L	Green Chemistry	Theory Only	1.0	3	0	0	0	3.0

Skill Enhancement									
S.No	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	PENG501P	Technical Report Writing	Lab Only	1.0	0	0	4	0	2.0
2	PSTS501P	Qualitative Skills Practice	Soft Skill	1.0	0	0	3	0	1.5
3	PSTS502P	Quantitative Skills Practice	Soft Skill	1.0	0	0	3	0	1.5

## **Discipline Core**

Course Code	Course Title	L	T	P	C
PCHY501L	Physical Chemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<div>1. Enriching the understanding of the significance of laws of thermodynamics and understand the calculations of absolute entropy and fugacity.</div> <div>2. Appreciating the significance of the kinetics of complex reactions, theories of unimolecular gaseous reactions, homogeneous and heterogeneous catalysis and enzyme catalysis.</div> <div>3. Understanding mathematical aspects of quantum chemistry and their applications.</div> <div>4. Recalling Nernst equation and understand Debye-Huckel theory of electrolytic conductance, Kohlrausch's law and understand the theory of conductometric and potentiometric titrations.</div>					
Course Outcomes					
<div>1. Recall the concepts of a Carnot theorem for heat engines.</div> <div>2. Solve problems related to thermodynamic properties of ideal &amp; real gases and entropy of a system.</div> <div>3. Analyze kinetics of complex, unimolecular and chain reactions.</div> <div>4. Relate the requirements of quantum mechanics for chemical systems.</div> <div>5. Apply Nernst equation, Debye-Huckel theory and Kohlrausch's law.</div> <div>6. Interpret electronically excited state dynamics and kinetic behavior of chemical systems.</div> <div>7. Recall the concepts on adsorption isotherms, kinetics and thermodynamics of surface reactions.</div> <div>8. Explain properties of surface active agents and their thermodynamics of micellazation.</div>					
Module:1	Classical Thermodynamics I	5 hours			
Review of laws of thermodynamics- Carnot cycle, Efficiency of heat engine, Entropy, entropy calculations - Free energy, criteria for spontaneity, Free energy as function of Temperature and Pressure. Chemical potential – Fugacity - Activity coefficient – Applications of free energy. 3 <sup>rd</sup> law of thermodynamics – Absolute entropy.					
Module:2	Chemical Kinetics I	7 hours			
Empirical Rate Laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants - Lindemann and Rice-Ramsperger- Kassel (RRK); unimolecular reactions; Kinetics of parallel – opposing reactions - chain reactions (hydrogen-halogen reactions).					
Catalysis-Homogeneous catalysis-heterogeneous catalysis-enzyme catalysis-Michaelis-Menton kinetics, salt effects - Inhibition effects - Autocatalysis.Catalysis-					

Homogeneous catalysis- heterogeneous catalysis-enzyme catalysis-Michaelis-Menton kinetics, salt effects - Inhibition effects - Autocatalysis.		
<b>Module:3</b>	<b>Quantum Chemistry I</b>	<b>6 hours</b>
Wave-particle dualism, Uncertainty principle. Operators for dynamic variables – Eigen values and Eigen functions; Postulatory basis of quantum mechanics; Schrödinger wave equation.		
<b>Module:4</b>	<b>Quantum Chemistry II</b>	<b>7 hours</b>
Particle in a box, one and three-dimensional, quantum numbers, zero point energy, orthogonalisation and normality, finite potential barrier – tunneling. The Rigid Rotator, One Dimensional Harmonic Oscillator, Solutions to hydrogen atom. Variation theorem - Time dependent wave function.		
<b>Module:5</b>	<b>Electrochemistry I</b>	<b>5 hours</b>
Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; Electrolytic conductance – Kohlrausch’s law and its applications; ionic equilibria; conductometric and potentiometric titrations.		
<b>Module:6</b>	<b>Photophysical Chemistry I</b>	<b>7 hours</b>
Review of concepts and laws of photochemistry- Brief review of electronic transition, Frank- Condon principle, selection rules, construction of Jablonski diagram, electronic transitions and intensity of absorption bands; Excited state kinetics, quantum yield expressions, excimer and exciplex, kinetics of luminescence quenching: Phosphorescence, fluorescence quenching: concentration quenching, static and dynamic, deviation from Stern-Volmer kinetics.		
<b>Module:7</b>	<b>Surface Chemistry and Colloids</b>	<b>6 hours</b>
Surface tension, adsorption on solids, Thermodynamics of surfaces, Gibbs Adsorption Isotherm, Heat and Entropy of adsorption. Study of surfaces – Freundlich, Langmuir and BET adsorption isotherms - study of kinetics of surface reactions. Properties and stability of colloids, surface active agents, reverse micelles, critical micellar concentration (CMC), factors affecting CMC of surfactants, thermodynamics of micellazation, microemulsions.		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
	<b>Total Tutorial hours:</b>	<b>15 hours</b>
<b>Text Book(s)</b>		
1.	P. W. Atkins and Julio de Paula, Atkins’ Physical Chemistry, 2018, International 11 <sup>th</sup> Edition, Oxford University Press, United Kingdom.	
2.	Ira N. Levine, Quantum Chemistry, 7 <sup>th</sup> Edition, 2014, Pearson Prentice Hall, London.	
<b>Reference Books</b>		
1.	K. J. Laidler, Chemical Kinetics, 1987, 3 <sup>rd</sup> Edition, Harper & Row, New York.	
2.	R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry, 2015, 4 <sup>th</sup> Ed., Wiley, India.	

3.	R. S. Berry, S. A. Rice and J Ross, Physical Chemistry, 2001, 3 <sup>rd</sup> Edition, Wiley, New York.		
4.	A.K. Chandra, Quantum Chemistry, 4 <sup>th</sup> edition, McGraw Hill Education, 2017, India.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY501P	Physical Chemistry Lab-I	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Training in operating different instruments used in the analysis of various chemical Constituents.					
Course Outcomes					
1. Experiment with potentiometry, conductometry, fluorimetry, colorimetry, kinetics and chromatography.					
2. Apply concepts of physical and analytical chemistry through experiments.					
Indicative Experiments					
1.	Estimation of Ferrous ion by Potentiometry				6 hours
2.	Construction of phase diagram of three component system.				6 hours
3.	Conductometric titration of mixture of acids against a strong base.				6 hours
4.	Adsorption of acetic acid on charcoal - Verification of Freundlich				6 hours
5.	Evaluation of Arrhenius parameters: Activation Energy and Frequency				6 hours
6.	Kinetics of oxidation of Iodide by Persulphate.				6 hours
7.	Determination of the distribution coefficient for iodine between different immiscible solvents.				6 hours
8.	Determination of concentrations of potassium and calcium in real samples using Flame Photometry				6 hours
9.	Estimation of chlorophyll in leaves by colorimetry				2 hours
10.	Determination of quinine by Fluorimetry and comparison of quantum efficiencies				2 hours
11.	Determination of stoichiometry of metal complexes using spectrophotometry (Job's method)				4 hours
12.	Separation of (a) mixture of Azo dyes by TLC (b) mixture of metal ions by Paper chromatography (demo)				4 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Advanced Physical Chemistry Practical Guide, Charu Arora, Sumantra Bhattacharya, Bentham Science Publishers, 2022.				
2.	Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000.				
Reference Books					
1.	Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan, Viva Books Private Limited, 2015.				

2.	Analytical Chemistry, International Adaptation, Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, 7 <sup>th</sup> Edition, Wiley, 2020.		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY502L	Inorganic Chemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Explaining structure, bonding and reaction mechanism involved in inorganic solids and metal complexes.					
2. Applying concepts of inorganic chemistry in research and development.					
Course Outcomes					
1. Compare the trends in the properties of main group elements and discuss the chemistry of Si, B, C- based compounds.					
2. Explain the structural arrangement in metals, ionic, covalent compounds and inorganic solids.					
3. Discuss theories of coordination chemistry.					
4. Interpret the reaction mechanism in metal complexes.					
5. Outline the concepts of organometallics.					
6. Justify the importance of nuclear chemistry in energy generation.					
Module:1	Chemistry of p-block elements	6 hours			
Introduction-Periodic trends- Silicones, silicates, silanes, phosphazenes. Boranes: Synthesis, bonding and structure. Carboranes and borazines. Sulfur Nitride (SN) <sub>x</sub> , Carbon Nitride (CN) <sub>x</sub> , Boron Carbon Nitride (BCN) <sub>x</sub> , HSAB Theory.					
Module:2	Structure and bonding	6 hours			
Close packing: Types of close packing in metals, packing in ionic crystals. Ionic solids: Pauling's rules for ionic crystals - ionic radii and covalent radii. Metal Clusters. Metallic bonding and Hydrogen bonding.					
Module:3	Inorganic solids	5 hours			
Ionic solids - NaCl, CsCl, TiO <sub>2</sub> , CaF <sub>2</sub> and ZnS – 3D structure -polyhedral approach. Defects in Crystal: Frenkel, Schottky and other defects.					
Covalently bonded compounds - CdI <sub>2</sub> , NiAs, MoS <sub>2</sub> .					
Module:4	Coordination chemistry-I	9 hours			
Introduction-CFT: splitting of d orbitals under various geometries, factors affecting splitting- spectrochemical series – Jahn-Teller distortion - application to spinels - limitations of CFT. Ligand Field Theory and MO theory: types of complexes - sigma - pi bonding of complexes, back bonding(carbonyls) - Nephelauxetic effects.					
Module:5	Coordination chemistry-II	6 hours			
Reaction mechanisms: Labile and inert complexes - ligand displacement reactions in octahedral and square planar complexes. Trans effect: theory and applications. Electron transfer reactions: Innersphere and outer sphere process.					
Module:6	Organometallic Chemistry	6 hours			
Types of ligands in organometallic compounds - eighteen Electron rule, alkyl compounds, metalcarbonyls, isolobal concepts. Metallocenes: Ferrocene.					
Module:7	Nuclear chemistry	5 hours			



Stability of nuclides, nuclear energy, isotope separation (specific to U), Types of decay, radioactive equilibrium, different types of nuclear reactions, q value and nuclear reaction cross section, neutronactivation analysis.					
<b>Module:8</b>		<b>Contemporary Issues</b>		<b>2 hours</b>	
Industry Expert Lecture					
		<b>Total Lecture hours:</b>			<b>45 hours</b>
		<b>Total Tutorial hours:</b>			<b>15 hours</b>
<b>Text Book(s)</b>					
1.	D.F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edition, 2010.				
2.	J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, 2014.				
3.	F.A. Cotton and G. Wilkinson Advanced inorganic Chemistry, John Wiley & Sons, 6th Ed., 1999.				
<b>Reference Books</b>					
1.	J.E. Huheey, E.A. Kelter and R.L. Kelter, Principles of structure and reactivity, Inorganic Chemistry, Harper Collins College Publishers, 4th Edition, 2011.				
2.	C.N.R. Rao, Muller and A. K. Cheetham, Chemistry of Nanomaterials, Vol. I & II, WileyVCH Verlag GmbH KGaA, 2014.				
3.	Lesley E. Smart, Elaine A. Moore, Solid State Chemistry: An Introduction, CRC Press, 4thEdition, 2012.				
4.	Walter D. Loveland, David J. Morrissey, Glenn T. Seaborg, Modern Nuclear Chemistry, Wiley-Interscience, 1st edition, 2001.				
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar					
Recommended by Board of Studies				26-02-2024	
Approved by Academic Council				No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY502P	Inorganic Chemistry Lab I	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Applying the concepts of qualitative and quantitative analyses of inorganic samples					
2. Developing skills for synthesis and characterization of inorganic materials					
Course Outcomes					
1. Recall and apply the principle of analysis of salt mixture.					
2. Estimate the metal content in alloy specimens.					
3. Develop the skill of nanomaterial synthesis.					
4. Adapt methodologies for real time sample analysis					
Indicative Experiments					
1.	Qualitative analysis of inorganic cations - Semi-micro qualitative analysis of a mixture of salts containing two common cations (Pb, Bi, Ca, Cd, Fe, Cr, Al, Co, Ni,Mn, Zn, Ba, Sr, Mg) and less common cations (W, Se, Mo, Ce, Th, Zr, V, Li): simple salt mixtures				30 hours
2.	Quantitative Analysis of Inorganic Materials 1. Determination of copper and nickel in an alloy 2. Simultaneous spectrometric determination of chromium and manganese in an alloysteel.				6 hours 6 hours
3.	Synthesis and Characterization of 1. Prussian blue 2. Silver nanoparticles				6 hours 6 hours
4.	Challenging Experiment Synthesize a chalcogenide or oxide based phosphor material used in displays. (i) Confirm the composition by appropriate techniques (ii) Prove the phosphorescence of the material				6 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Vogel's Qualitative Inorganic Analysis, G. Svehla and B. Sivasankar, 7 <sup>th</sup> edition, Pearson, 2012.				
Reference Books					
1.	Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6 <sup>th</sup> Edition, Prentice Hall, 2000.				
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT					
Recommended by Board of Studies				26-02-2024	
Approved by Academic Council				No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY503L	Organic Chemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Explaining the basic concepts on organic reactions and mechanism including stereochemical and conformational aspects.					
2. Application of spectroscopic techniques for characterization of organic compounds.					
Course Outcomes					
1. Recall the fundamental principles of organic reactions and mechanism.					
2. Illustrate nomenclature, isomerism and stereochemistry in organic molecules.					
3. Analyze the stereochemistry of products in organic reactions.					
4. Apply chemoselectivity, regioselectivity and enantioselectivity for organic reactions of industrial significance.					
5. Determine the influence of the substituents on substrate molecules and nature of solvent.					
6. Interpret the structure of organic molecules using spectroscopy.					
Module:1	Art of arrow pushing and reactive intermediates	9 hours			
Flow of electrons – electron source (nucleophile) and electron sink (electrophile), bond making and bond breaking. Common mistakes in arrow pushing – Backward arrow, not enough arrow, hyper valency, mixed media error, conservation of charge, oxidation state and delocalization. General aspects, structure, stability and fate of the intermediates and chemical reactions involving classical and non-classical carbocations, carbanions, free radicals, carbenes, nitrenes and arynes.					
Module:2	Introduction to Stereochemistry and conformational analysis	9 hours			
Assigning <i>R</i> & <i>S</i> configuration at chiral centers – one & two chiral center, <i>meso</i> compounds. Illustrations of erythro and threo nomenclature.					
Atropisomerism in $sp^2$ and $sp^3$ carbons with specific example. Racemic mixture, optical purity - enantiomeric excess, Cis-Trans geometrical isomerism and E, Z notations. Introduction to atropisomerism. Conformational analysis of acyclic, mono cyclic and bicyclic system: simple 1,2 disubstituted ethane derivatives, cyclohexane, mono, di and tri-substituted cyclohexane, cis and trans decalins. s-cis and s-trans conformations in butadiene.					
Module:3	Substitution and elimination reactions	8 hours			
Mechanism - Effect of substrate, nucleophile and solvents on - $S_N1$ , $S_N2$ , $S_Ni$ , $S_N1'$ , $S_N2'$ , $S_Ni'$ reactions with specific examples. Aromatic Nucleophilic Substitution ( $S_NAr$ ) - Vicarious mechanism - Nucleophilic substitution involving diazonium ions - Balz Schimann reaction-Von-Richter rearrangement. Elimination reactions - 1,2; 1,3, 1,4 and pyrolytic-eliminations- E1, E1cB, E2 mechanism, stereo- selectivity in E2 reaction, Saytzeff vs. Hoffmann elimination.					
Module:4	Electrophilic and nucleophilic addition reaction to C-C double bond	5 hours			
Syn and anti-additions. Reaction mechanisms in hydroboration, addition of					

alcohols, dienes, thiols, hydrogen cyanide, bisulphite anions and hydride ions. Conversion of alkenes to diols (Manganese, Osmium based), Prevost reaction and Woodward modification.			
<b>Module:5</b>	<b>Aromatic Electrophilic substitution</b>		<b>5 hours</b>
Electrophilic substitution in mono and disubstituted aromatic systems : Nitration, bromination and Friedel Crafts reaction			
<b>Module:6</b>	<b>Addition to carbon-hetero atom multiple bond</b>		<b>5 hours</b>
Aldol and Knoevenagel reactions and its stereoselectivity (syn- & anti-), reactions of enamine, Mannich reaction, Perkin reaction, Addition of Grignard reagent, and Stobbe reactions, Claisen ester condensation, Benzoin condensation, Darzens glycidic ester condensation, Reformatsky reaction, McMurry coupling, Michael addition and Robinson annulation.			
<b>Module:7</b>	<b>Structural elucidation using spectroscopic techniques</b>		<b>7 hours</b>
Fundamental principles of the following spectroscopic techniques can be discussed: UV- Vis, IR, NMR and Mass spectrometer. Application of these spectroscopic techniques in problem solving for organicmolecules.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
	<b>Total Tutorial hours:</b>		<b>15 hours</b>
<b>Text Book(s)</b>			
1.	Ernest L.Eliel, Stereochemistry of carbon compounds, Tata McGrawhill Edition, 2001.		
2.	J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, andStructure, 6th Edition, Wiley, 2013.		
3.	Peter Sykes, A Guidebook to Mechanism in Organic Chemistry, 6 <sup>th</sup> Edition, Pearson EducationLtd., England, 2013.		
<b>Reference Books</b>			
1.	I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011.		
2.	W. Carruthares, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition,Cambridge University Press, Fourth Edition, 2015.		
3.	F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part A & B: Reaction and Synthesis,Springer, 5 <sup>th</sup> Edition, 2010.		
4.	R. M. Silverstein, G. C. Bassler, T. C. Morrill, Spectrometric identification of OrganicCompounds, John Wiley & Sons, Inc, 2010.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY503P	Organic Chemistry Lab I	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Developing skills in organic synthesis 2. Creating knowledge in separation, analysis and spectroscopic interpretation of organic compounds					
Course Outcomes					
1. Analyze organic mixtures and functional groups of molecules using various reagents. 2. Evaluate product distribution based on reaction conditions and spectroscopic techniques.					
Indicative Experiments					
1.	Separation and qualitative Organic analysis of binary mixture I				6hours
2.	Separation and qualitative Organic analysis of binary mixture II				6hours
3.	Separation and qualitative Organic analysis of binary mixture III				6hours
4.	Separation and qualitative Organic analysis of binary mixture IV				6hours
5.	Separation and qualitative Organic analysis of binary mixture V				6hours
6.	Training on separation/purification techniques (TLC, column and distillation)				6hours
7.	Training on separation/purification techniques (recrystallization, extraction, Soxhlet extraction, etc.)				6hours
8.	Synthesis and characterization of Endo-cis-1,4- endoxo -2,3-dicarboxylic acid (IR , UV , GCMS, NMR).				6hours
9.	Synthesis and characterization of 3-Pyridyl-4(3H) quinazalone (IR, UV, GCMS, NMR ).				4hours
10.	Synthesis and characterization of Flavone using Baker-Venkatraman Synthesis(IR, UV, GCMS, NMR ).				4 hours
11.	Synthesis and characterization of Anthracene-Maleic anhydride adduct (IR, UV, GCMS, NMR ).				4 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India; 5th edition, 2003.				
2.	Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000.				
Reference Books					
1.	Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Private Limited, 2008.				

2.	The Systematic Identification of Organic Compounds, R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson, 7 <sup>th</sup> edition, John Wiley & Sons, New York, 1997		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY504L	Group Theory and Molecular Spectroscopy	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Applying practical aspects of quantum chemistry, spectroscopy, symmetry, and group theory indifferent research problems.					
2. Explaining the concepts of rotational, vibrational, electronic and NMR spectroscopy.					
Course Outcomes					
1. Define symmetry and symmetry operations in molecules.					
2. Make use of group theory in molecular spectroscopy.					
3. Demonstrate the practical implementation of quantum chemistry in spectroscopy.					
4. Apply the quantum chemistry, group theory and molecular spectroscopy to solve real world problems.					
5. Outline the basic physical aspects of NMR spectroscopy.					
Module:1	Fundamentals of Group Theory	6 hours			
Symmetry elements and symmetry operations-group multiplication table-subgroups, similarity transformations and classes- identifications of symmetry operations and determination of point groups- reducible and irreducible representations-Mullikan symbols.					
Module:2	Applications of Group Theory	7 hours			
Orthogonality theorem and its consequences - construction of character table for linear (CO2, HCl, N2) and non- linear molecules (H2O, CH4, XeF4, BF3, SF6 and NH3). Determination of representations of vibrational modes in linear and non-linear molecules.					
Symmetry adapted linear combinations, symmetry aspects of MO theory, sigma- and pi-bonding in AB4(tetrahedral) molecule.					
Symmetry selection rules of infra-red and Raman spectra - application of group theory for the electronic spectra of ethylene and formaldehyde.					
Module:3	Fundamentals of molecular spectroscopy	6 hours			
The basis of absorption and emission of radiation by molecular species, the wave properties of the light, the quantum theory of light, quantum theory of matter, molecular energies and the Born Oppenheimer approximation, the types of molecular motion and spectroscopy associated with each.					
Module:4	Rotational Spectroscopy	6 hours			
Classical description of molecular rotation, quantum mechanics of molecular motion, rotational spectra, determination of the bond length from rotational constants, vibrational stretching and vibrational satellites, no-rigid rotor, centrifugal distortion, degeneracies and intensities, Stark effect, selection rules, rotational spectra of polyatomic molecules.					
Module:5	Vibrational Spectroscopy	6 hours			

Interaction of Electromagnetic radiation with matter - The Vibrating Diatomic Molecule - harmonic and anharmonic oscillators- Diatomic Vibrating Rotator - Vibrations of polyatomic molecules-Molecular vibrations, types of molecular vibrations. Fundamentals, overtones, combination bands and Fermi resonance, fingerprint region. Application of IR - characteristic group frequencies in organic molecules and metal carbonyls.		
<b>Module:6</b>	<b>Electronic Spectra of molecules</b>	<b>6 hours</b>
The Born-Oppenheimer Approximation, Vibrational Coarse structure: Progressions, Intensity of vibrational-Electronic spectra: Franck-Condon Principle, Dissociation Energy, Dissociation Products and Predissociation. The Woodward Fisher rules – calculation of $\lambda_{\max}$ for dienes, enones and polyenes – Use of UV spectroscopy in distinguishing geometrical isomers. Effect of solvents on spectra - solvatochromism. Applications of electronic spectra.		
<b>Module:7</b>	<b>Magnetic resonance spectroscopy</b>	<b>6 hours</b>
Nuclear Spin Origins, Spin and Magnetic Properties, Nuclear Spin Angular Momentum and Quantum Numbers, Magnetic Moment of a Nucleus Nuclear Energy Levels in a Magnetic Field, Classical Description of the NMR Experiment and the principle, Experimental Verification of Quantized Angular Momentum and of the Resonance Equation, Types of NMR spectroscopy, applications.		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
	<b>Total Tutorial hours:</b>	<b>15 hours</b>
<b>Text Book(s)</b>		
1.	Colin N Banwell, Elaine M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw-HillPublishing Co. Ltd., 5th Edition, 2013.	
2.	P. W. Atkins and Julio de Paula, Atkins’ Physical Chemistry, International 11 <sup>th</sup> Edition, Oxford University Press, United Kingdom, 2018.	
3.	Understanding NMR Spectroscopy, James Keeler, Wiley India Pvt Ltd; Second edition, 2013.	
4.	F.A. Cotton, Chemical Applications of Group Theory, 3 <sup>rd</sup> Edition, Wiley India Edition, 2009.	
<b>Reference Books</b>		
1.	D. A. McQuarrie, Quantum Chemistry, 2 <sup>nd</sup> Edition, University Science Books, 2008.	
2.	Hollas J. Michael Hollas, Modern Spectroscopy, John Wiley & Sons Inc. 4th Edition, 2003.	
3.	A.K. Chandra, Introduction to Quantum Chemistry, Tata Mc Graw Hill Publishing Company,New Delhi, 4 <sup>th</sup> Edition, 2009.	
4.	P. S. Kalsi, Spectroscopy of Organic Compounds, 6 <sup>th</sup> Edition. New Age International Publishers,6th Edition, 2006.	



5.	F. Hammer, Inorganic Spectroscopy and Related Topics, Sarup & Sons, 1 <sup>st</sup> Edition, 2008.		
6.	P. K Bhattacharya, Group theory and its applications, 3 <sup>rd</sup> Edition, Himalaya Publishing House, 2007.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY505L	Organic Synthesis and Methodologies	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Acquainting various methodologies used in organic synthesis, which enable the student to think different possible ways to synthesis an organic compound					
2. Knowing various metallic reagents used in chemical transformations in the production natural and synthetic drugs and materials.					
Course Outcomes					
1. Recall the fundamental principles of organic reactions.					
2. Outline the concepts related to synthesis, mechanisms and the functions of various reagents.					
3. Apply their understanding about the retrosynthetic approaches involved in organic reactions of industrial significance.					
4. Analyze the product distribution and the stereochemistry of various organic products through spectroscopic data.					
5. Evaluate the organic reactions and methodologies based on the influence of the substituents on substrate molecules and nature of solvent and the parametric conditions.					
6. Propose new organic reactions to achieve the required retro- synthesis products.					
Module:1	C-C & C-X Disconnection approach	3 hours			
An introduction to synthons and synthetic equivalents, disconnection approach, functionalgroup inter conversions. One group and two group C-X disconnections in 1,2-, 1,3-, 1,4- and 1,5-difunctional compounds. One group and two group C-C Disconnections; Alcohols and carbonyl compounds regioselectivity, Diels-Alder reaction, 1,3-di functional compounds.					
Module:2	Planning and execution of retrosynthesis	5 hours			
Retro synthesis of alkenes, acetylenes, nitro and amine compounds with specific example tosynthesis of simple molecule for each functional group					
Module:3	Strategies of alcohols and carbonyl disconnections	4 hours			
Alcohols and carbonyl compounds with specific example to synthesis of simple molecule foreach functional group					
Module:4	Retro-synthesis of carbonyl and heterocyclic compounds	5 hours			
Unsaturated carbonyl compounds, control in carbonyl condensations, Michael addition andRobinson annulation. Retro synthesis of aromatic heterocycles of 5 and 6 membered rings.					
Module:5	Types of Asymmetric synthesis	6 hours			
Asymmetric synthesis - Substrate, auxiliary, reagent, catalyst controlled methods (organo and metal catalysis)					
Module:6	Heterocycles with fused 6 membered rings	7 hours			
Dicyclohexylcarbodiimide (DCC), EDCI, DDQ, Organozinc (Reformatsky reaction), Organo lithium (Shapiro reaction, LDA), Organocopper (Gillman reagent,					

Ullmann), organopalladium (Sonogashira and Stille), organosilicon (Peterson's synthesis), organotin (tributyl tinhydride)			
<b>Module:7</b>	<b>Protection, deprotection and total synthesis</b>		<b>10 hours</b>
Alcohol, acid, amine, ketone and aldehyde. Total synthesis of Camptothecins, Longifolene and Cubane - chemoselectivity.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Stuart Warren and Paul Wyatt, Organic synthesis, the disconnection approach, 2 <sup>nd</sup> edition, Wiley, 2012.		
2.	Jie Jack Li, E. J. Corey, Total Synthesis of Natural Products: At the Frontiers of Organic Chemistry, First Edition, Springer, 2012.		
3.	Rainer Mahrwald, Enantioselective Organocatalyzed Reactions, 322 & 386 Pages, 1 <sup>st</sup> Edition, Springer, 2011.		
4.	K. C. Nicolaou, E. J. Sorensen-Classics in total synthesis- 4 <sup>th</sup> edition, Wiley-VCH (1996)		
5.	Michael B Smith, Organic synthesis, 4 <sup>th</sup> Edition, Academic Press (2016)		
<b>Reference Books</b>			
1.	I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011.		
2.	W. Carruthares, Iain Coldham, Modern Methods of Organic Synthesis South Asia Edition, Cambridge University Press, Fourth Edition, 2015.		
3.	Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure. 7 <sup>th</sup> Edition, Wiley, 2017.		
4.	L. S. Starkey, Introduction to Strategies for Organic synthesis. Wiley & Sons, Inc., Hoboken, New Jersey and Canada. 2012		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY506L	Organometallics and Industrial Applications	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
<b>Course Objectives</b>					
1. Explaining the basic concepts of organometallics, their reactions and reaction mechanisms					
2. Imparting knowledge on applications of various organometallic reagents.					
<b>Course Outcomes</b>					
1. Explain synthesis, mechanism and functions of organometallic reagents and catalysts.					
2. Demonstrate the importance of organometallic compounds.					
3. Analyse the spectral data of organometallic compounds.					
<b>Module:1</b>	<b>Introduction</b>	<b>5 hours</b>			
Energy, Polarity, Lability & Reactivity aspects of main group organometallic chemistry; Transition metal compounds – The 18 valence electron rule, nomenclature of organometallic compounds, Significance of metal - carbon bonds in catalysis.					
<b>Module:2</b>	<b>Preparation methods, stability</b>	<b>5 hours</b>			
Bonding theory, synthesis and reactivity of sigma-bonded alkyls and aryls, metal carbonyls and pi-bonded organic ligands such as alkenes, alkynes, allyls, and arenes, applications.					
<b>Module:3</b>	<b>Metal carbonyls, metallocenes, carbenes and carbynes</b>	<b>5 hours</b>			
Metal Carbonyls – Preparation methods, Properties, important reaction types – Nature of carbonyl metal hydrides; Metallocenes and other sandwich - inverted and half- sandwich compounds; Metal carbenes and carbynes (alkylidenes, alkylidyne)s. Nucleophilic and electrophilic carbene complexes.					
<b>Module:4</b>	<b>Olefin complexes, homoalkene and heteroalkene complexes</b>	<b>5 hours</b>			
$C_3R_3^+$ , $C_4H_4$ and $C_5H_5$ - ligands - Cyclopentadienyl metal carbonyls, halides and their special applications; Multi metal clusters – Formation and criteria for M-M bonds; isolobal analogy.					
<b>Module:5</b>	<b>Important synthetic routes and properties</b>	<b>9 hours</b>			
Organosilanes, organoboranes and organometallic complexes of platinum group metals (Ru, Rh, Pd, Os, Ir and Pt), $\beta$ -Hydride elimination, Oxidative addition, Reductive elimination, ligand substitution, migratory insertion, trans metalation, nucleophilic attack on the ligand. Agostic interactions in organometallic complexes; Organometallic polymers - synthesis, important properties and applications.					
<b>Module:6</b>	<b>C-C Coupling reactions</b>	<b>9 hours</b>			
Pd catalyzed cross-coupling reactions; Boron- Suzuki reaction; Tin- Stille reaction; Lithium & Magnesium- Kumada coupling; Zinc- Negishi reaction; Silicon- Hiyama reaction; Copper-Sonogashira reaction; Heck Reaction. Activation & functionalization of sp, sp <sup>2</sup> and sp <sup>3</sup> hybridized molecules (CO, CO <sub>2</sub> and CH <sub>4</sub> ).					

<b>Module:7</b>	<b>Structural elucidation</b>		<b>5 hours</b>
Structural elucidation of organometallic complexes, fluxional molecules.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Basic Organometallic Chemistry: Concepts, Syntheses, and Applications of Transition Metals, B.D. Gupta, Anil J. Elias, Universities Press, 2 <sup>nd</sup> edition, 2013.		
2.	A Text Book on Organometallics, Christoph Elschenbroich, 3 <sup>rd</sup> revised edition, WILEY- VCH, Germany, 2006.		
3.	The Organometallic Chemistry of the Transition Metals Robert H. Crabtree, 6 <sup>th</sup> edition, John Wiley & Sons, Inc., 2014.		
<b>Reference Books</b>			
1.	Organic Synthesis Using Transition Metals, Roderick Bates, 2 <sup>nd</sup> Edition, John Wiley & Sons, Ltd., 2012		
2.	Applied Homogeneous Catalysis with Organometallic Compounds: A Comprehensive Handbook in Four Volumes, Boy Cornils, Wolfgang A. Herrmann, Matthias Beller, Rocco Paciello (Eds), Wiley-VCH Verlag GmbH & Co. KGaA, 2017.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

## **Discipline Elective**

Course Code	Course Title	L	T	P	C
PCHY601L	Analytical Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<ol style="list-style-type: none"><li>1. Making students understand the insights of statistical methods in qualitative and quantitative analysis and usage of different analytical instruments for chemical analysis.</li><li>2. Realizing the importance of thermal analysis, absorption and emission spectroscopy, surface analytical, electroanalytical, and chromatographic techniques.</li></ol>					
Course Outcomes					
<ol style="list-style-type: none"><li>1. Analyze different errors using statistical methods in Chemical analysis.</li><li>2. Evaluate errors in chemical analysis through statistical treatment of data through F- test, T-test and Q-test.</li><li>3. Relate thermal behavior of different organic and inorganic materials using TGA, DTA and DSC</li><li>4. Apply absorption and emission techniques for trace element analysis from different matrices.</li><li>5. Utilize diffraction and microscopic techniques to characterize nanomaterials.</li><li>6. Analyze electroactive species using different voltammetric techniques.</li><li>7. Make use of TLC and Paper chromatographic techniques for monitoring and detection of important organic and inorganic materials.</li><li>8. Determine organic compounds using GC and HPLC techniques.</li></ol>					
Module:1	Errors and Statistical treatment	8 hours			
Errors in chemical analysis. Classification of errors- systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Calculations involving significant figures. Confidence limit, correlation coefficient and regression analysis. Comparison of methods: F-test and T-test. Rejection of data based on Q-test. Least squares method for deriving calibration graph. Fitting of data to hypothesis.					
Module:2	Thermoanalytical methods	6 hours			
Types – Thermogravimetric Analysis (TGA) – Factors influencing TGA – Instrumentation of TGA - Applications of TGA for analysis of inorganic compounds and polymers. Differential thermal analysis (DTA) - Theory - instrumentation and applications in food and pharmaceutical industry. Differential Scanning Calorimetry (DSC) -Theory - instrumentation and applications in polymer and pharmaceutical industries.					
Module:3	Atomic Absorption, Flame Emission and Inductively coupled plasma Analysis	5 hours			
Atomic Absorption spectroscopy and Flame Emission Spectroscopy - Basic					

principles- Instrumentation – analytical applications. ICP-MS/OES - Basic principles- sources of radiation - instrumentation - analytical applications.		
<b>Module:4</b>	<b>Material Characterization Techniques</b>	<b>6 hours</b>
XRD, SEM, TEM, EDAX, AFM - Basic Principles, instrumentation and their utility in characterization of nanomaterials		
<b>Module:5</b>	<b>Electroanalytical Techniques</b>	<b>6 hours</b>
Polarography - Introduction, Dropping mercury electrode (DME), Instrumentation, Ilkovic equation and its verification, Determination of half wave potential, applications. Voltammetry – A three electrode system concept – diffusion-controlled and adsorption-controlled electron-transfer reactions; Single sweep voltammetry, cyclic voltammetry - Randles-Sevcik equation, Criteria for reversible and irreversible processes - applications.		
<b>Module:6</b>	<b>Basics of TLC and Paper Chromatography</b>	<b>6 hours</b>
Thin-layer chromatography (TLC): Principle, methodology selection of stationary and mobile phases- preparation of plates, spotting, development, identification and detection, measurement of RF values, Qualitative and quantitative applications. Paper chromatography (PC): Theory and principle; techniques: one, two-dimensional and circular PC, mechanism of separation, structure of cellulose and types of paper, methodology, sample preparation, choice of solvents, location of spots and measurement of RF value, factors affecting RF values, advantages and applications		
<b>Module:7</b>	<b>Introduction to HPLC and GC</b>	<b>6 hours</b>
Gas chromatography (GC): Principle, instrumentation columns - packed and tubular, factors affecting separation, applications. High pressure liquid chromatography (HPLC): Apparatus, pumps, column packing, detectors-UV, IR and fluorescence detectors, advantages and applications.		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
<b>Text Book(s)</b>		
1.	Gary D. Christian, Purnendu (Sandy) Dasgupta, Kevin Schug, Analytical Chemistry, Wiley & sons, 7 <sup>th</sup> Edition, 2013.	
2.	Douglas A Skoog, Donald M West, F James Holler, Stanley R.Crouch, Fundamentals of Analytical Chemistry, Wadsworth Publishing Co Inc., 9th Edition, 2014.	
3.	H.A. Willard, L.L.Meritt, J.A. Dean, Von Nostrand, Instrumental Methods of Analysis, 7th Edition, CBS Publishers, 1986.	
<b>Reference Books</b>		
1.	S.M. Khopkar, Analytical Chemistry: Problems and Solutions, New Age International Pvt. Ltd., 2 <sup>nd</sup> Edition, 2010.	



2.	J. Basset, R.C. Denny, C.H. Jaffery and J. Mendhan, Vogel's Text Book of Quantitative Chemical Analysis, ELBS, Longman Group Publishers, 6 <sup>h</sup> Edition, 2009.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY602L	Advanced Organic Chemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Explaining the basic concepts on organic reactions and mechanism including stereochemical and conformational aspects.					
2. Application of spectroscopic techniques for characterization of organic compounds.					
Course Outcomes					
1. Recall the fundamental concepts related to organic reactions.					
2. Explain synthesis, mechanism and the functions of reagents and catalysts.					
3. Apply the organic reactions to make industrially important molecules.					
4. Analyze product distribution and stereochemistry of products using spectroscopy.					
5. Relate the influence of substituents on substrate molecules, nature of solvent and reaction parameters.					
6. Propose organic reactions to achieve the required products.					
Module:1	Classical to modern oxidation methods	7 hours			
Oxidation of alcohols - Chromium, Manganese, Aluminum, Silver, Ruthenium. Swern, Dess-Martin periodinane and TEMPO based reagents, N-hydroxyphthalimide reagent. Alkene to epoxides - Sharpless, Jacobsen and Shi epoxidation (chiral). Ketones to ester and lactones.					
Module:2	Oxidative cleavage and addition	6 hours			
Oxidative cleavage of alkenes - Manganese, Osmium, Ruthenium, Lead, Ozone Oxidative addition of alkenes - hydroboration, Wacker oxidation, Selenium, Chromium based allylic oxidation.					
Module:3	Reduction by metals	8 hours			
Heterogeneous - Palladium/Platinum/Rhodium/Nickel Homogeneous: Wilkinson; Noyori asymmetric hydrogenation Reduction by alkali metals – Li / Na in liquid ammonia – Birch reduction Reduction by transition metals: Zinc and Titanium reagents, SmI <sub>2</sub> (Acyloin formation, dehalogenation and deoxygenations) Reduction by metal catalyst - Meerwein-Ponndorf-Verley reduction Enantioselective reductions - Chiral Boranes, Corey-Bakshi-Shibata reduction					
Module:4	Reduction by metal hydrides	6 hours			
Reduction by metal hydrides - NaBH <sub>4</sub> , triacetoxyborohydride, LiAlH <sub>4</sub> , L-selectride, K-selectride, Luche reduction; DIBAL-H, and Red-Al, Trialkylsilanes and Trialkylstannane					
Module:5	Rearrangement reactions	5 hours			
Carbocation - Pinacol-pinacolone, Wagner Meerwein, Demjanov Carbanion – Favorskii (5-9 membered ring systems), Stevens, Neber Carbene – Wolff rearrangement; Nitrene - Hoffman, Curtius, Schmidt. N-Heterocyclic Carbenes in Metal Catalysis and organo catalysis.					
Module:6	Carbohydrates and peptides in organic synthesis	7 hours			

Reactivity at carbon center - reactions at anomeric carbon and epimeric carbons, ring expansions and contractions. Protection and deprotection methods in carbohydrate.			
Chemical and enzymatic glycosylations to oligosaccharides - Modification of sugars into carbocycles and heterocycles and their applications in medicinal chemistry (one example each).Peptides: Synthesis of peptides, protection and deprotection methods in peptide synthesis.			
Module:7	Modern Synthetic Methods		4 hours
Baylis-Hillman reaction, Henry reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction. Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Suzuki, Negishi			
Module:8	Contemporary Issues		2 hours
Industry Expert Lecture			
	Total Lecture hours:		45 hours
	Total Tutorial hours:		15 hours
Text Book(s)			
1.	F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5 <sup>th</sup> Edition, 2010.		
2.	J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and structure, 6th Edition, Wiley, 2013.		
3.	L. Kuerti and B. Czako, Strategic Applications of named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.		
Reference Books			
1.	I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011.		
2.	W. Carruthers, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition, Cambridge University Press, Fourth Edition, 2015.		
3.	F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5 <sup>th</sup> Edition, 2010.		
4.	R.M. Silverstein, G. C. Bassler, T. C. Morrill, Spectrometric identification of Organic Compounds, John Wiley & Sons, Inc, 2010.		
5.	Nolan, S. P. N-Heterocyclic Carbenes in Synthesis; Wiley-VCH; Weinheim, 2006.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY603L	Chemistry of Heterocyclic Compounds	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Explaining synthesis methods, and applications of heterocyclic compounds. 2. Learning the physical and chemical behaviour of heterocyclic compounds and their reaction mechanisms.					
Course Outcomes					
1. Recall fundamental aspects of heterocyclic compounds. 2. Explain nomenclature, structure, reaction mechanisms and functions of heterocyclic compounds. 3. Make use of organic reactions to synthesize heterocyclic molecules of industrial importance. 4. Analyze product distribution and stereochemistry of heterocyclic derivatives using spectroscopic tools. 5. Relate the influence of substituents on substrate molecules, nature of solvent and reaction parameters.					
Module:1	Systematic nomenclature of heterocycles	3 hours			
Hantzsch-Widman system for monocyclic, fused and bridged heterocycles					
Module:2	Aliphatic and carbocyclic aromatic heterocyclic compounds	8 hours			
Carbocyclic aromatic system-six members and fused, tautomerism in heterocycles-spectroscopic properties of heterocyclic systems (any two). Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, oxetanes, thietanes. Corey-Chaykovsky epoxidation. Darzen, Aza Darzen condensation, DeKimpe - thiranes, azetidines.					
Module:3	Five membered Heterocycles	5 hours			
Synthesis and reactions of Furans: Fiest Benary furan synthesis, Knorr and Paal-Knorr pyrrole synthesis, Pyrroles and pyrrolidines-Barton. Zard reaction. Hofmann-Löffler-Freytag reaction. Thiophenes-Hinsberg synthesis of thiophene derivatives. Oxazoles and isoxazoles- Robinson- Gabriel ring closure. Cornforth rearrangement. Larock synthesis.					
Module:4	Six and Large Membered Heterocycles	8 hours			
Pyridines- Hantzsch (Dihydro)-pyridine synthesis, Doebner von Miller reaction, pyrimidines- Biginelli reaction, Chichibabin (Tschitschibabin) pyridine synthesis. Synthesis and reactions of azepines, oxepines, thiepines, diazepines (1,2 and 1,4), thiazepines, azocines.(any four)					
Module:5	Heterocycles with fused 5 membered rings	6 hours			
Synthesis and reactions of heterocycles with fused 5 membered ring benzopyrroles, benzofurans and benzothiophenes, Indoles: Fischer, Madelung, Nenitzescu syntheses.					
Module:6	Heterocycles with fused 6 membered rings	7 hours			

Heterocycles with fused 6 membered ring Quinolines and isoquinolines- Bischler-Napieralski reaction. Friedlander synthesis. Meth-Cohn quinolone synthesis. Pfitzinger quinoline synthesis., Skraup synthesis, Coumarins, chromones, quinolizinium ions			
<b>Module:7</b>	<b>Industrial and Medicinal Applications of Heterocyclic Compounds</b>		<b>6 hours</b>
PEDOT and polypyrroles as conducting polymers, Bipyridine in dye sensitized solar cells (DSC). Nicotinic acid (Lipid modulating drug), 3,5-pyrazolidinedione (anti-inflammatory drug),Captopril (anti-hypertensive agent) and Ciprofloxacin (antibiotic).			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Heterocyclic Chemistry At A Glance, John A. Joule, Keith Mills, 2 <sup>nd</sup> revised edition Wiley-Blackwell, 2012.		
2.	The Chemistry of Heterocycles, Theophil Eicher, Siegfried Hauptmann, 3 <sup>rd</sup> edition, Wiley-VCH, Weinheim, 2012.		
3.	An Introduction to the Chemistry of Heterocyclic Compounds, Acheson, R. M. 3rd Edition, WileyIndia Pvt Ltd, 2008.		
4.	Heterocyclic Chemistry, Gilchrist, T. L. , 3 <sup>rd</sup> Edition, Prentice Hall, 2005.		
<b>Reference Books</b>			
1.	Organic Chemistry, Jonathan Clayden, Nick Greeves, and Stuart Warren, Oxford University Press, 2014.		
2.	The essence of Heterocyclic Chemistry, Arun R Parikh, Hansa Parikh and Ranjan Khunt, New Age International, 2017.		
3.	Heterocyclic Chemistry, V. K. Ahluwalia, Alpha Science International, 2012.		
4.	Advanced Organic Chemistry: Structure and Mechanisms (Part A &B). Frances A Carey and Richard J Sundberg, Springer, 2015.		
5.	Heterocyclic chemistry, R. K. Bansal, 5 <sup>th</sup> edition, New Age International Private Limited, 2017.		
6.	Name reactions in heterocyclic chemistry, Jie Jack Li, Wiley India Pvt Ltd, 2012.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY604L	Chemistry of Natural Products	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Explaining synthesis, properties, medicinal applications, metabolic activities and biological functions of natural products.					
2. Acquainting the students with steroids and their biological functions.					
Course Outcomes					
1. Relate the structural difference between different natural products.					
2. Outline chemical synthesis and biosynthesis of natural products like steroids, alkaloids, terpenoids, flavonoids and pigments.					
3. Determine the structure of natural products using structural elucidation methods.					
4. Demonstrate the importance of natural products based on their bioactivities.					
Module:1	Steroids	5 hours			
Classification, general structural elucidation and identification tests- Synthesis, structural elucidation, stereo chemistry and conformational aspects of cholesterol.					
Module:2	Synthesis of Steroids	5 hours			
Synthesis and structural elucidation of oestrone. Conversion of cholesterol into androsterone, testosterone, progesterone and bile acids.					
Module:3	Alkaloids	9 hours			
Classification, general structural elucidation and identification tests-Structural elucidation and chemistry of the following alkaloids: quinine, morphine, reserpine, mosembrine.					
Module:4	Terpenoids	5 hours			
Classification, mevalonic lactose, structural elucidation and synthesis of bisabolene, longifoleneand caryophyllene.					
Module:5	Flavanoids and Pigments	9 hours			
Anthocyanins and anthocyanidines, general methods of synthesis. Synthesis and structure offlavonols, isoflavonols, isoflavones.					
Introduction to pigments, classification, isolation and synthesis of apigenin, quercetin, diadzein, cyanidin and cyanin.					
Module:6	Vitamins	5 hours			
Chemistry and synthesis of Vitamin B complexes, Vitamin C and Vitamin D					
Module:7	Carbohydrates	5 hours			
Pyranose and furanose forms of aldohexose and ketohexose - methods used for the determination of ring size - conformation of aldohexopyranose – structure and synthesis of maltose, lactose, sucrose and cellobiose – A brief study of starch and cellulose.					
Module:8	Contemporary Issues	2 hours			
Industry Expert Lecture					
	Total Lecture hours:				45 hours
Text Book(s)					

1.	Natural Products in the Chemical Industry, Bernd Schaefer, 2nd ed. Springer, New York, 2014.		
2.	Organic Chemistry, Vol II, Stereochemistry and the Chemistry of Natural Products, I. L. Finar, 5th edition, Pearson, 2009.		
<b>Reference Books</b>			
1.	Advanced Organic Chemistry, Part-A and B, F. A. Carey and R. J. Sundberg, 5 <sup>th</sup> edition, Springer, 2008.		
2.	Strategies and Tactics in Organic Synthesis, Michael Harmate, 1 <sup>st</sup> Edition, Elsevier, 2013.		
3.	Organic Chemistry of Natural Products, Volume II, O. P. Aggarwal, 38 <sup>th</sup> edition, Krishna Prakashan Media (P) Ltd, 2014.		
4.	Medicinal Natural Products, P. M. Dewick, 3 <sup>rd</sup> edition, John Wiley, 2011.		
5.	Chemistry of Natural Products, Sujata V. Bhat, Bhimsen A. Nagasampagi, Meenakshi Sivakumar, Narosa Publishing House, 2013.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY605L	Photochemistry and Pericyclic Reactions	4	0	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1.Imparting knowledge on theory and applications of photochemistry and pericyclic reactions.					
2.Explaining mechanisms of reactions involved in organic synthesis using cycloaddition and photochemistry.					
Course Outcomes					
1.Recall the fundamental principles of photochemical reactions.					
2.Relate the concepts related to light induced organic synthesis, mechanisms and functions of reagents.					
3.Apply photochemical reactions for synthesising molecules of industrial significance.					
4.Analyse product distribution and stereochemistry of products derived from photochemical reactions.					
5.Evaluate the photochemical reactions based on the influence of the substituents on substrate molecules.					
6.Propose photochemical reactions to achieve the required products.					
Module:1	Principles of photochemical reactions	11 hours			
Molecular energies and Jablonski diagram. Photochemical reactions and their applications in organic synthesis; Hund's and Frank Condon principle, Photochemistry of carbonyl compounds, Paterno- Buchi reaction, Norrish type I and II reaction, Photoreduction, Photochemistry of $\alpha,\beta$ unsaturated compounds, olefins and isomerization.					
Module:2	Photo rearrangements	5 hours			
Di- $\pi$ -methane, oxa di- $\pi$ -and aza di- $\pi$ -methane, aromatic hydrocarbons, Wolf and Friesrearrangements.					
Module:3	Significant photoreactions	11 hours			
Photocycloaddition, Photochemical aromatic substitution reaction; Reactions with singlet oxygen, ene reactions (ene with oxygen, alkenes, carbonyl, alkynes, amines etc.); Photochemical methods for protection and deprotection.-Barton reaction and Hoffman-Löffler-Freytag reactions, The mechanisms of reactions involving free radicals- Sandmayer, Gomberg- Bachmann, Pschorr and Hunsdiecker reactions. Photo-elimination reactions					
Module:4	Aromaticity and cross-conjugated Systems	6 hours			
Aromaticity in benzenoid and non-benzenoid compounds. Huckel's $(4n+2)$ and $4n$ rules, annulenes, anti-aromaticity and homo-aromaticity. Annulenones, Annulenequinones, Fulvenes. Polycyclic Systems-Cyclopropenyl Aromatic Systems-Pentalenes, Heptalenes, Azulenes, Other Systems-Cyclobutadiene and cyclooctatetraene.					
Module:5	Molecular orbital symmetry	7 hours			
Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system, Wood-					



ward Hoffman correlation diagrams, FMO and PMO approach, electrocyclic reactions, - conrotatory and dis rotatory motions, $4n$ , $4n+2$ and allyl systems			
<b>Module:6</b>	<b>Sigma-tropic rearrangement</b>		<b>7 hours</b>
Supra and antarafacial shifts of H Sigmatropic shifts involving carbon moieties,3,3 and 5,5 sigmatropic rearrangement and Claisen and Cope , Oxa and Aza Cope rearrangement- HOMO-LUMO orbital symmetry analysis. Cheletropic Reactions			
<b>Module:7</b>	<b>Cycloaddition</b>		<b>11 hours</b>
Supra and antarafacial additions, $4n$ and $4n+2$ systems, 2+2 additions of ketenes, 1,3-dipolar cycloaddition and cheletropic reactions. Ene reaction.			
<b>Diels-Alder reactions:</b> retro Diels-Alder reaction- FMO mechanism for <i>endo</i> - and <i>exo</i> -selectivity, stereochemistry, inter- and intramolecular reactions. Correlation diagrams and FMO method, Allowed and forbidden reactions. Nazarov and Iso Nazarov reactions			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>60 hours</b>
<b>Text Book(s)</b>			
1.	Orbital interactions in chemistry, Thomas A Albright, Jeremy Burdett, Myung-Hwan Whangbo, 2 <sup>nd</sup> edition, John Wiley & Sons, Inc., 2013		
2.	Pericyclic reactions-A Textbook: Reactions Applications and Theory, S. Sankararaman, Wiley-VCH, 2015.		
3.	Organic Photochemistry and Pericyclic Reactions, S. Kalaivanai, MJP Publishers, 2011.		
<b>Reference Books</b>			
1.	Pericyclic reactions, Sunil Kumar, Vinod Kumar, S.P. Singh, Elsevier, 2016.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY606P	Organic Chemistry Lab-II	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Imparting training in analysis of organic compounds using chemical and instrumental methods.					
2. Developing skills in organic synthesis.					
3. Demonstrating the importance of different instrumental methods in chemical analysis of materials.					
Course Outcomes					
1. Recall synthetic utility of organic molecules and reagents.					
2. Outline the preparation methods of organic molecules and reaction mechanisms.					
3. Analyse the structure of synthesized organic molecules and their derivatives using chemical analysis and spectroscopic tools.					
Indicative Experiments					
1.	Estimation of Phenol	6 hours			
2.	Estimation of Aniline	6 hours			
3.	Estimation of Glucose	6 hours			
4.	Estimation of Methyl Ketone	6 hours			
5.	Estimation of carbonyl group (percentage purity of carbonyl compound)	6 hours			
6.	Synthesis, characterization of phenytoin from benzoin- two step reactions(IR, UV, GCMS, NMR)	6 hours			
7.	Synthesis, characterization of 2,3-diphenyl quinoxaline (from benzil) (IR,UV, GCMS, NMR)	6 hours			
8.	Synthesis characterization of 2-phenylindole from acetophenone - two stepreactions (IR, UV, GCMS, NMR)	6 hours			
9.	Synthesis, characterization of tetrahydrocarbazole from cyclohexanone-(Fischer Indolization) (IR, UV, GCMS, NMR)	6 hours			
10.	Synthesis, characterization of methyl cinnamate from malonic acid throughcinnamic acid two step reactions (IR, UV, GCMS, NMR)	6 hours			
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India; 5th edition, 2003.				
2.	Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000.				
3.	An advanced course in practical chemistry, Nad A. K., Mahapatra B, and Ghoshal A. New Central Book Agency (P) Ltd, 2011.				
4.	Instrumental techniques for Analytical Chemistry, Frank Settle, Prentice Hall PTR, New Jersey, USA, 1997.				
Reference Books					
1.	Techniques and Experiments for Organic Chemistry, Addison Ault, University				

	Science Book, USA, 1998.		
2.	The Systematic Identification of Organic Compounds, R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson, 7th edition, John Wiley & Sons, New York, 1997		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY607P	Organic Chemistry Lab-III	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Developing skills in organic synthesis. 2. Demonstrating the art of extraction and separation of organic molecules. 3. Imparting training in analysis of organic compounds using chemical and instrumental methods					
Course Outcomes					
1. Apply organic synthesis methodologies to prepare important organic molecules. 2. Demonstrate preparation methods, functions of various reagents and reaction mechanisms. 3. Analyse product distribution and the influence of reaction conditions in terms of yields. 4. Evaluate the properties of synthesized molecules and their derivatives using spectroscopic tools.					
Indicative Experiments					
1.	Synthesis, characterization of methyl salicylate from salicylic acid: one-step (IR, UV, GCMS, NMR)				6 hours
2.	Synthesis, characterization of methyl red from anthranilic acid: two-step process (IR, UV, GCMS, NMR)				6 hours
3.	Synthesis, characterization of $\alpha$ , $\beta$ -Unsaturated acid from anisaldehyde - two step Knoevenagel condensation/hydrolysis (IR, UV, GCMS, NMR)				6 hours
4.	Synthesis, characterization of Poly Halo-arene (1-iodo-2,4,6-tribromo benzene from aniline) - two step (IR, UV, GCMS, NMR)				6 hours
5.	Synthesis, characterization of trimethylquinoline from p-toluidene - two step (IR, UV, GCMS, NMR)				6 hours
6.	Multi step synthesis: 2-aminobenzophenone-2-methyl-3-aceylquinoline-2-methylquinoline chalcone				6 hours
7.	Multi step synthesis: Cinnamaldehyde- cinnamyl alcohol- cinnamylbromide - allylaryl ether				6 hours
8.	Extraction and characterization of Lactose from Milk				5 hours
9.	Extraction and characterization of Lycopene from Tomatoes				5 hours
10.	Separation of binary mixture by column chromatography - non-polar and polar compounds				8 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India; 5th edition, 2003.				
2.	Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000.				
4.	An advanced course in practical chemistry, Nad A. K., Mahapatra B, and				

	Ghoshal A. New CentralBook Agency (P) Ltd, 2011.		
5.	Instrumental techniques for Analytical Chemistry, Frank Settle, Prentice Hall PTR, New Jersey, USA, 1997.		
Reference Books			
1.	Techniques and Experiments for Organic Chemistry, Addison Ault, University Science Book, USA, 1998.		
2.	The Systematic Identification of Organic Compounds, R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson, 7 <sup>th</sup> edition, John Wiley & Sons, New York, 1997.		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY608L	Electroanalytical and Separation Techniques	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Getting insight into advanced voltammetric and amperometric technique in analysis of electroactive species.					
2. Understanding the working principle and applications of ion-selective electrodes.					
3. Explaining theoretical principles and practical applications of chromatographic techniques.					
Course Outcomes					
1. Apply advanced voltammetric techniques.					
2. Analyse toxic metal ions and anions using ion selective electrodes.					
3. Make use of GC and GC-MS techniques for the analysis of volatile organic compounds.					
4. Evaluate different chiral and bio molecules by separating them using HPLC, UPLC and LC-MS.					
5. Apply super critical fluid chromatography for extraction.					
6. Interpret separation of biological molecules using affinity chromatography.					
7. Apply the principles of capillary electrophoresis for biological applications.					
Module:1	Advanced Voltammetric Techniques	6 hours			
Normal pulse voltammetry, Differential pulse voltammetry, Square wave voltammetry & Stair case voltammetry – Principle, procedure and applications.					
Stripping voltammetry - Anodic & Cathodic stripping - Applications.					
Amperometry: Basic principles, instrumentation, nature of titration curves, and analytical applications.					
Module:2	Ion Selective Electrodes	6 hours			
Working principles and applications- theoretical considerations - types of ion-selective electrodes – properties of ion-selective electrodes – sources of errors – construction and working of cation specific electrodes for analysis of cadmium, lead, arsenic and anion specific electrodes for fluoride, chloride and sulphide ions.					
Module:3	Gas Chromatography	7 hours			
Instrumentation - Carrier Gas – Packed and Capillary Column, Types of Stationary Phases and Column Selection). Injection Methods (On-column, Split/Split-less and Programmed Temperature Vaporizer) Temperature Control - Common detector systems.					
Sampling Methods - Sample Selection & Preparation and Injection -. GC Method Development - Troubleshooting - Quantitative and Qualitative Applications – Hyphenated Systems (GC/MS).					
Module:4	Liquid Chromatography	8 hours			
HPLC Columns - Types, Packing Characteristics and Modern Column Trends of HPLC Columns - Specialty Columns (Chiral and Bio-Separation). Stationary Phases (Normal and Reverse-phase) - Mobile Phases (Selection of Mobile Phase,					

Isocratic and Gradient Elution) - Sample Preparation and Introduction- HPLC Method Development - Preparative HPLC - Troubleshooting - Quantitative and Qualitative Applications - Hyphenated Systems (LC/MS).		
<b>Module:5</b>	<b>UPLC and Super critical fluid chromatography</b>	<b>7 hours</b>
UPLC: Ultra performance liquid chromatography, stationary phases for UPLC, specific applications. Supercritical Fluid chromatography: Principle - super critical fluids, properties of supercritical fluids- Instrumentation, detectors, injection techniques, pressure restrictors, specific applications. Ion Chromatography: principle, applications in qualitative and quantitative analysis.		
<b>Module:6</b>	<b>Affinity Chromatography</b>	<b>4 hours</b>
Definitions, separation mechanism-matrices, matrix activation, role of spacer arms and applications in purification of biological molecules.		
<b>Module:7</b>	<b>Capillary Electrophoresis</b>	<b>5 hours</b>
Overview, types, the basis for electrophoretic separations, migration rates and plate heights, electroosmotic flow, instrumentation, capillary zone electrophoresis, capillary gel electrophoresis, capillary isoelectrophoresis, capillary isoelectric focusing, applications.		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
	<b>Total Tutorial hours:</b>	<b>15 hours</b>
<b>Text Book(s)</b>		
1.	Richard G. Compton and Craig E. Banks, Understanding Voltammetry, 2 <sup>nd</sup> Revised Edn., WorldScientific Publishers, 2011.	
2.	Konstantin N. Mikhelson, Ion-Selective Electrodes, Springer-Verlag, 2013.	
3.	Gary D. Christian, Purnendu K. Dasgupta and Kevin A. Schug, Analytical Chemistry, 7 <sup>th</sup> edition, John Wiley & Sons, Inc., 2014.	
4.	Daniel C. Harris and Chucky Lucy, Quantitative Chemical Analysis, 9 <sup>th</sup> Edn., W.H. Freeman,2015.	
5.	Mark F. Vitha, Chromatoraphy: Principles and Instrumentation, John Wiley & Sons, Inc., 2017.	
6.	A. Braithwaite and F.J. Smith, Chromatographic Methods, 5th Edition, Blackie Academic &Professional (Chapman & Hall), 2009.	
<b>Reference Books</b>		
1.	Danilo Corradini, Handbook of HPLC, CRC Press Taylor and Francis, 2011.	
2.	C.F. Poole, Gas Chromatography, Elsevier Inc., 2012.	
3.	Yuki Saito and Takumi Kikuchi, Voltammetry - Theory, Types and Applications, Nova SciencePublishers, Inc. 2014.	
4.	M. Anderson, A. Fitch and J. Stickney, Chemically Modified Electrodes, Electrochemical Society,2015	

5.	Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, 7 <sup>th</sup> Edn., Cengage Learning Publishers, 2018.		
6.	C.F. Poole S.K. Poole, Chromatography Today, 5th Edition, Elsevier Science, 1991.		
7.	Hans-Joachim Hubschmann, Hand Book of GC-MS, Fundamentals and Applications, Wiley-VCH,2009.		
8.	Robert E. Ardrey, Liquid Chromatography-Mass Spectrometry-An Introduction, Wiley, 2003.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024



Course Code	Course Title	L	T	P	C
PCHY609L	Environmental and Industrial Analytical Chemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding soil analysis and waste management. 2. Learning the effects of pollutants in water, air and food and their analysis. 3. Identifying the different industrial pollutants and prevention methods.					
Course Outcomes					
1. Analyze trace elements in soil by chemical analysis. 2. Evaluate parameters to be controlled in solid waste and adopt methods for reduction and recycling of solid waste. 3. Analyze water quality through different analytical methods. 4. Apply absorption and emission spectroscopy and chemical analysis for water pollutants. 5. Analyze air quality and adopt methods for reduction of air pollutants. 6. Evaluate industrial pollutants, understand their effects and adopt methods to reduce them. 7. Identify contaminants present in food and water such as pesticides and additives.					
Module:1	Chemical analysis of soil	5 hours			
Soil/Sediment analysis: a brief idea of chemistry of soil. Trace element analysis in soil - B, Cd,Cu, Fe, Mn, Mo, Zn, Pb. Standard specifications for soil					
Module:2	Soil based Waste Management	5 hours			
Waste Management: waste management approaches - waste reduction, recycling, disposal. Management of hazardous wastes, household waste, municipal and industrial wastes-collection, transportation and disposal options.					
Module:3	Water quality assessment	6 hours			
Determination of pH, EC, TDS, DO, colour, turbidity, total solids, conductivity, acidity, alkalinity hardness, chloride, fluoride, sulphate, nitrite, nitrate, phosphorous (total inorganic and organic),BOD, COD, TOC, pesticides.					
Module:4	Water pollutants & their Impact	6 hours			
Sources of water pollution - domestic, industrial, agricultural, soil and radioactive wastes as sources of pollution. Contamination by inorganic and organic materials - parameters for analysis. Impact of heavy metal pollution- Assessment of toxic metal ions in water; Impact of organic pollutants - Assessment of dyes and other organic pollutants in water.					
Module:5	Air quality monitoring	6 hours			
Air quality; Air Analysis: atmospheric pollution, classification of air pollutants, sources of air pollution and methods of control, sampling of aerosols, sampling of gaseous pollutants, analysis of SO2, NO2, CO-CO2, hydrocarbons, particulates, effects of air pollutants on animals, ozone layer, chlorofluorocarbons, acid rain and greenhouse effect.					
Module:6	Industrial pollutants and prevention	7 hours			
Pollutants from Pigment and paint, textile industries, tannery, cosmetics					

ceramics and glass, chemical and pharmaceutical, explosives, electroplating industries, food processing industries. Pollution prevention strategies in industrial processes.			
<b>Module:7</b>	<b>Food ingredients, additives and contaminants</b>		<b>8 hours</b>
Water in food, crude protein and amino acids - functional properties; lipids - classification and use of lipids in food - physical and chemical properties, nutritive value; carbohydrates-functional properties in food; minerals, vitamins, ash content. Pesticide analysis in food products. Food additives; chemistry, role and application of preservatives; emulsifying, stabilizing, buffering, bleaching, maturing agents and starch modifiers, food color, flavors, anti-caking agents. Common adulterants in food, contamination of food stuffs.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
		<b>Total Lecture hours:</b>	<b>45 hours</b>
		<b>Total Tutorial hours:</b>	<b>15 hours</b>
<b>Text Book(s)</b>			
1.	Pradyot Patnaik, Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil and Solid Wastes, 3rd Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2018.		
2.	Timothy J. Sullivan, Alan T. Herlihy and James R. Webb, Air Pollution and Freshwater Ecosystems: Sampling, Analysis, and Quality Assurance, CRC Press, Boca Raton, FL, Taylor & Francis Group, LLC, 2015.		
<b>Reference Books</b>			
1.	Eugene W. Rice, Rodger B. Baird, Andrew D. Eaton, Lenore S. Clesceri, Standard Methods for Examination of Water and Wastewater, 22 <sup>nd</sup> Edition, American Public Health Association, 2012.		
2.	Leo M.L. Nollet, Leen S. P. De Gelder, Handbook of Water Analysis, 3 <sup>rd</sup> Edition CRC Press, Taylor & Francis Group, Boca Raton, FL, 2013.		
3.	Leo M.L. Nollet and Fidel Toldra, Handbook of Analysis of Active Compounds in Functional Foods, CRC Press, Boca Raton, FL, Taylor & Francis Group, 2012.		
4.	Sadhana Chaurasia, Anand Dev Gupta, Hand Book of Water, Air and Soil Analysis,International E- Publication, 2014.		
5.	Bernie Goldman, Air Pollution and Environmental Analysis, Callisto Reference, 2017.		
6.	Paul Mac Berthouex, Linfield C. Brown, Chemical Processes for Pollution Prevention and Control, 1 <sup>st</sup> Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2018.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY610L	Bioanalytical and Forensic Analysis	4	0	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<div>1. Understanding the principles of antigen-antibody interactions, immunoanalytical techniques, Immunodiffusion and immunofluorescent assays.</div> <div>2. Getting insight into forensic toxicology and biochemical, physical and chemical methods of forensic analysis.</div>					
Course Outcomes					
<div>1. Demonstrate Antigen-Antibody interactions and apply them in biological analysis.</div> <div>2. Analyze samples using immunodiffusion and electrophoresis techniques</div> <div>3. Apply radioisotope dilution techniques in tracer analysis.</div> <div>4. Evaluate biological samples through ELISA, ELISPOT and Western Blotting techniques</div> <div>5. Analyze biological samples using fluorescent immunoassays using DELFIA, SLFIA, FACS and PACIA techniques.</div> <div>6. Demonstrate fundamental aspects of forensic toxicology.</div> <div>7. Analyze narcotics, stimulants, depressants, hallucinogens, alcohol, metabolites in blood and other matrices.</div>					
Module:1	Antigen-Antibody/Protein-ligand Interactions: Principles and Applications	10 hours			
Structure and characteristics of antibodies, polyclonal and monoclonal antibodies, Concepts and applications of Antigen-Antibody Interactions, Strength and Characteristics of Antigen - Antibody Interaction; Zone of Equivalence and its significance in analysis- Antibodies and Enzymes as analytical reagents. Cross-Reactivity - quantitative and qualitative analysis of antigens.					
Module:2	Immunoanalytical Techniques	8 hours			
The principle of single and double immunodiffusion. Electrophoresis - Gel, SDS-PAGE, Immuno and Capillary. Isotope dilution techniques - Principles and applications- radioisotope dilution techniques - Use of radioisotope tracer techniques in biochemical experiments and their detection.					
Module:3	Immunodiffusion and Immunoassays	6 hours			
Principles of Enzyme-linked immunoassays - types - direct, indirect, sandwich and competitive ELIS techniques - use of Chemiluminescence in ELISA - ELISPOT Assay; Western blotting - principles, procedures and applications.					
Module:4	Fluorescence Immunoassays	6 hours			
Principles of fluorescence immunoassays - substrate labelled fluorescent immunoassay (SLFIA) - delayed enhanced lanthanide fluorescence immunoassay (DELFIA)- flow cytofluorimetry and fluorescence-activated cell sorting (FACS) - particle counting immunoassays (PACIA).					
Module:5	Introduction to Forensic Analysis and Forensic	10 hours			

	<b>Toxicology</b>			
Introduction to forensic science, role of a forensic scientist, theory of forensic analysis: comparative analysis, Classification of poisons based on physical states; study of common poison; mode of action, chemical properties; methods of administration and their action in the body. Analysis of drug of abuse: opiates, hallucinogens, depressants, stimulants and club drugs; breath testing of alcohol, collection and preservation of drug evidence, qualitative and quantitative analysis by colour tests, microcrystalline tests. Simultaneous analysis of multianalytes.				
<b>Module:6</b>	<b>Forensic Analysis of Biological Samples</b>			<b>8 hours</b>
Analysis of biological samples (Qualitative and Quantitative): Blood, semen, urine and saliva. Blood spatter analysis, DNA analysis. Hairs and fiber analysis, fingerprint analysis; Isolation, sample preparation.				
<b>Module:7</b>	<b>Physical and Chemical Methods of Analysis in Forensic Science</b>			<b>10 hours</b>
Forensic analysis of explosives and gunshot residues, paints, arsons, and questioned documents. Lie detection – introduction, process, merits and demerits. Application of mass, GC-MS, FT-IR, SEM in forensic analysis. Applications of non-destructive testing probes including radiography, Xera- radiography Surface penetrations methods (SEM and Laser Probes), application of spectroscopic, chromatographic techniques such as GC-MS, FT-IR, UV-Visible spectroscopy, Atomic absorption spectroscopy for forensic sample analysis.				
<b>Module:8</b>	<b>Contemporary Issues</b>			<b>2 hours</b>
Industry Expert Lecture				
	<b>Total Lecture hours:</b>			<b>60 hours</b>
<b>Text Book(s)</b>				
1.	Howard Harris, Henry C Lee, Introduction to forensic science and criminalistics, Second edition, 2019, CRC Press.			
2.	Anil K Sharma, Immunology: An Introductory Textbook, 2019, Pan Stanford Publishing Ltd.			
<b>Reference Books</b>				
1.	A Lucas, Forensic Chemistry, 2017, Forgotten Books.			
2.	Max M. Houck, Forensic Chemistry (Advanced Forensic Science Series), 2015 Academic Press.			
3.	Richard Saferstein, Criminalistics: An Introduction to Forensic Sciences, 2015, Pearson Education.			
4.	Judith A. Owen, Jenni Punt, Sharon A. Stranford, Patricia P. Jones, Kuby Immunology, 7 edition, 2013), W H Freeman & Co.			
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar				
Recommended by Board of Studies			26-02-2024	
Approved by Academic Council			No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY611L	Analytical Quality Assurance for Process Industry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding the importance of different methods that are used for assuring quality in different process industries.					
2. Getting inputs on existing Quality Assurance methods used in different process industries including good manufacturing practices.					
3. Knowing the significance of Quality assurance in automated process industries					
Course Outcomes					
1. Evaluate the parameters to be maintained to achieve consistent quality in process industry.					
2. Apply the principles of ISO 9000 for management of quality in industry.					
3. Compose SOPs and GLPs in setting up Quality Management System					
4. Propose appropriate sampling methods for chemical analysis.					
5. Apply Statistical Quality control methods to solve quality issues in industry.					
6. Create flow sheets for automated processes and quality assurance					
Module:1	Basic concepts of Quality Assurance	5 hours			
Basic concepts, Principles or prescription; Needs, requirements and expectations; The characteristics of quality; Achieving, sustaining and improving quality; Quality dimensions and costs of quality.					
Module:2	Quality Assurance	6 hours			
Elements of quality Assurance, Quality Management System Quality management concepts and principles: ISO 9001:2000					
QMS Case studies on ISO 9001: 2000 in chemical industries. ISO 14000 Series of Standards					
Module:3	TQM and Six sigma	8 hours			
TQM in Chemical Industry. Six Sigma Approach to Quality: Applying Six Sigma to chemical Industries. - Good Laboratory Practices: Principles of GLP, GMP in Drugs and Pharmaceutical Industries - Standard operating procedure (SOP) Accreditation of QC laboratories: Requirements of QMS; Establishing a QMS; Validation of methods and related case studies. Tools and Mechanisms ICH Guidelines on Drug substances and Products.					
Module:4	Sampling	5 hours			
Measurement, analysis and methods of improvement; Basics of sampling; Sampling procedures; Sampling based on physical state and hazards in sampling pre-concentration methods.					
Module:5	Statistical Quality Control	6 hours			
Statistical Quality Control Techniques: Statistical treatment of data. Control charts, Performance Evaluation uncertainties in measurement. Validation of analytical methods- Role of SQC in QCQA of process industry.					

<b>Module:6</b>		<b>Industrial QA</b>		<b>6 hours</b>	
Outlines of QA in chemical industries; Flow sheet preparations; Principles of process selection and unit operation. Outlines of QA in chemical industries; Flow sheet preparations; Principles of process selection and unit operation.					
<b>Module:7</b>		<b>Quality Assurance and Automation</b>		<b>7 hours</b>	
Automated and Automatic Process control; Automation in chemical process industry; Methods of automation: Flow injection and Sequential Injection; Quality assurance through automation.					
<b>Module:8</b>		<b>Contemporary Issues</b>		<b>2 hours</b>	
Industry Expert Lecture					
		<b>Total Lecture hours:</b>		<b>45 hours</b>	
<b>Text Book(s)</b>					
1.	R. Pannerselvam, Production and Operations Management, Prentice Hall India Learning Pvt. Ltd3 <sup>rd</sup> Edition, 2012.				
2.	Mehmet Savsar, Quality Assurance and management, InTech-Croatia, 2012.				
3.	D.C. Montgomery, Statistical Quality Control, John Wiley & Sons, 5th edition, 2005.				
4.	M. K. Starr, Production and Operations Management, Biztantra, Delhi, 2004.				
5.	D.H. Shah, QA Manual, Business Horizons, 2000				
6.	D.H. Besterfield, C. Besterfield-Michna, G.H. Besterfield, M. Besterfield -Sacre, Total QualityManagement, Pearson Education, Inc., 3rd Edition, 2003.				
<b>Reference Books</b>					
1.	Piotr Konieczka and Jack Namiesnik Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach, 1 <sup>st</sup> Edition, CRC press 2009.				
2.	David Hoyle, ISO 9000 Quality Systems Handbook, Fifth Edition, Butterworth-Heinemann-Elsevier, New York, 2006.				
3.	Elizabeth Prichard and Victoria Barwick, Quality Assurance in Analytical Chemistry, John Wiley& Sons, 2007.				
4.	Y. Anjaneyulu and R. Marayya, Quality Assurance and Quality Management in Pharmaceu <sup>t</sup> icallIndustry, Pharma Book Syndicate, 2005.				
5.	A. K. Chakraborty, P. K. Basu, S.C. Chakravarty, Guide to ISO 9001: 2000, Asian Books Pvt. Ltd.,2005.				
6.	B.W. Wenclawiak, M.Koch and E. Hadjicostas (Eds.), Quality Assurance in Analytical Chemistry, Springer, 2004.				
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar					
Recommended by Board of Studies				26-02-2024	
Approved by Academic Council				No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY612P	Analytical & Physical Chemistry Lab II	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
Analyzing various chemical constituents using instrumental techniques.					
Course Outcomes					
1. Apply standard addition method in titrimetric analysis.					
2. Propose experiments for analysis of inorganic and organic materials.					
3. Analyze constituents in materials using emission and absorption techniques.					
4. Apply electrochemical methods for analysis of electroactive species.					
Indicative Experiments					
1.	Standard addition method for estimation of Ascorbic acid in fruit juice				6 hours
2.	Estimation of chromium in steel sample by spectrophotometry				6 hours
3.	Determination of sodium carbonate in washing soda by pH titration				6 hours
4.	Determination of Indicator constant by spectrophotometry				6 hours
5.	Determination of dissociation constant (K <sub>a</sub> ) of weak electrolyte and verification of Debye-Huckel Onsager equation using strong electrolyte.				6 hours
6.	Estimation of sulphide in effluent using potentiometric titration				6 hours
7.	Determination of Stern-Volmer constant of Iodine quenching by fluorimetry				6 hours
8.	Cyclic Voltammetry				6 hours
9.	Determination of ascorbic acid in real samples using Differential Pulse Voltammetry and comparing with specifications				6 hours
10.	Determination of protein concentration using Bradford's method				6 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Advanced Physical Chemistry Practical Guide, Charu Arora, Sumantra Bhattacharya, Bentham Science Publishers, 2022.				
2.	Kissinger, Laboratory Techniques in Electroanalytical Chemistry, Second edition, CRC Press, 2016.				
Reference Books					
1.	R. Holze, Experimental Electrochemistry: A Laboratory Textbook, Second edition, Wiley-VCH, 2019.				
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT					
Recommended by Board of Studies				26-02-2024	
Approved by Academic Council				No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY613P	Analytical Chemistry Lab III	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding analysis of organic and inorganic compounds present in real life samples by instrumental methods.					
2. Demonstrating analysis of different contaminants in water and other matrices					
Course Outcomes					
1. Propose experiments for determination of metals in different matrices using instrumental methods.					
2. Analyze real samples and effluent samples for knowing the levels of different contaminants.					
3. Evaluate drugs and soft drinks using different titrimetric and instrumental methods of analysis.					
Indicative Experiments					
1.	Isolation and estimation of chromium from waste water by spectrophotometry				6 hours
2.	Analysis of oils and fats - Saponification and acid value				6 hours
3.	Determination of nitrate in different soil and water samples by spectrophotometry				6 hours
4.	Extraction and estimation of benzoic acid in fruit juices				6 hours
5.	Heavy metal analysis in textiles and textile dyes by AAS				6 hours
6.	Study of degradation of organic dyes by hydrogen peroxide catalyzed by copper and iron nanoparticles				6 hours
7.	Determination of caffeine in soft drinks by HPLC				6 hours
8.	Extraction of copper by diethyl dithiocarbamate and its spectrophotometric determination				6 hours
9.	Analysis of water quality through COD, DO, BOD measurements				6 hours
10.	Assay of Riboflavin and Iron in tablet formulations by spectrophotometry				6 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000.				
Reference Books					
1.	Analytical Chemistry, International Adaptation, Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, 7 <sup>th</sup> Edition, Wiley, 2020.				
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT					
Recommended by Board of Studies			26-02-2024		
Approved by Academic Council			No. 73	Date	14-03-2024



Course Code	Course Title	L	T	P	C
PCHY614L	Advanced Inorganic Chemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding structure, bonding and reactivity of transition metals, rare earth metals, and organometallics.					
2. Making the students realize the importance of bio-inorganic and inorganic photochemistry					
3. Explaining chemistry and applications of advanced materials					
Course Outcomes					
1. Recall electronic structure, bonding, and reactivity of coordination complexes.					
2. Outline synthesis and stability of transition metal organometallic complexes.					
3. Develop catalytic pathways leading to desired products.					
4. Apply the principles of transition metal coordination complexes in understanding functions of biological systems.					
5. Propose materials for energy generation, energy storage and magnetic applications.					
6. Interpret photochemical and electronic properties of coordination complexes.					
Module:1	Descriptive chemistry of transition metals and rare earths	6 hours			
Periodic trends – comparison of periodic properties by electronic configuration. Oxidation states –chemistry of various oxidation states, stabilization of unusual oxidation states. Heavier transition elements. Chemistry of uranium-compounds of uranium and their chemical properties.					
Module:2	Inorganic –Clusters and polyacids	5 hours			
Isopoly and heteropoly acids. Clusters - Polynuclear carbonyls- synthesis, reactivity, molecularStructure, stereochemical non-rigidity and Polyhedral Skeletal Electron-Pair Theory (PSPET).					
Module:3	Organometallic Catalysis	6 hours			
Catalytic cycles-oxidative addition and reductive elimination. Hydrogenation of olefins - hydroformylation of olefins - Fischer - Tropsch process - polymerisation of alkenes - Ziegler-Natta Catalyst - mechanistic Studies - Single-Site Catalysts - Metallocenes - Nonmetallocene Catalysts -olefin metathesis					
Module:4	Bioinorganic systems	7 hours			
Porphyrin systems: Dioxygen Transport - Hemoglobin, Hemerythrin and Hemocyanin. Cooperativity in O2 binding, O2 and CO discrimination. Inorganic model compounds. Oxygen Metabolism - Oxygen atom transfer by cytochromes- P450 - Nitrogenases - Carbonic anhydrase - Carboxypeptidase - Alcohol dehydrogenase - Photosystem.					
Module:5	Medicinal applications of bioinorganic compounds	5 hours			
Metal complexes in medicine- Cisplatin and its mode of action. Gold and Lithium compounds as drugs - Metal complexes as probes of nucleic acid, metal ions in					

genetic regulations, metal DNA and RNA interaction - Potential binding sites.		
<b>Module:6</b>	<b>Advanced materials</b>	<b>8 hours</b>
2D Layered advanced Materials - Graphene, Graphene Oxide, MXenes, MoS <sub>2</sub> , BN, BCN – synthesis, structural features, characterization, selected applications – electronic devices, watersplitting - photocatalysis - energy storage. Perovskite - Structure - Oxide to Halide Perovskites - Types of inorganic - organic perovskite solar cells - Stability; Manganese-doped cadmium selenide / cadmium sulphide quantum dots/nanocrystals - Photomagnetic effects.		
<b>Module:7</b>	<b>Inorganic Photochemistry</b>	<b>6 hours</b>
Photochemistry of Ru(II) and Cr(III) complexes - Porphyrin-based photosensitizers for photodynamic therapy - Photoactivation of small molecules like CO <sub>2</sub> and H <sub>2</sub> O by transition metal complexes		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
	<b>Total Tutorial hours:</b>	<b>15 hours</b>
<b>Text Book(s)</b>		
1.	Inorganic Chemistry, D. F. Shriver and P.W. Atkins, Oxford University Press, 5th Ed., 2010.	
2.	Concise Inorganic Chemistry, J. D. Lee, Oxford University Press, 5th Edition, 2014.	
3.	Bioinorganic Chemistry: An Introduction, Dieter Rehder, Oxford University Press, 1st Ed., 2014.	
4.	Homogeneous Catalysis - Mechanisms and Industrial Applications, S. Bhaduri, D. Mukesh, 2 <sup>nd</sup> Edition, Wiley, 2014.	
5.	Spectral Methods in Transition Metal Complexes, K. Sridharan, 1 <sup>st</sup> Edition, Elsevier, 2016.	
6.	X-ray photoelectron spectroscopy: An Introduction to Principles and Practices, Paul van der Heide, Wiley-Blackwell, 1 <sup>st</sup> Edition, 2012.	
<b>Reference Books</b>		
1.	Principles of structure and reactivity, Inorganic Chemistry, J.E. Huheey, E. A. Kelter and R.L. Kelter, Harper Collins College Publishers, 4th Edition, 2011.	
2.	C.N.R. Rao, Muller and A. K. Cheetham, Chemistry of Nanomaterials, Vol. I & II, C.N.R. Rao, Muller and A. K. Cheetham, WileyVCH Verlag GmbH KGaA, 2014.	
3.	Bioinorganic chemistry, D. Rehder, E. Nordlander, Oxford University Press India, 2014.	
4.	Inorganic Photochemistry, Van Eldik, Grazyna Stochel, Academic Press, 2011.	
5.	2D Inorganic materials beyond Graphene, Editors: C. N. R. Rao & U.V. Waghmare, WorldScientific Publishing Company, 2017.	
6.	2D Metal Carbides and Nitrides (MXenes) Structure, Properties and Applications, Editors: Babak Anasori & Yury Gogotsi, Springer, Cham, 2019.	
7.	Light-Induced Spontaneous Magnetization in Doped Colloidal Quantum Dots, R. Beaulac, L. Schneider, P. I. Archer, G. Bacher, D. R. Gamelin, Science, 2009,	

	325, 973-976.		
8.	Review of recent progress in chemical stability of perovskite solar cells, G. Niu, X. Guo, L. Wang, J. Mater. Chem. A, 2015, 3, 8970-8980		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY615L	Materials Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding the basic aspects of structure types of solids, polymers, composite materials and materials synthesis.					
2. Correlating the structure and property of materials for transport, optical and dielectric properties.					
Course Outcomes					
1. Categorize and recognize structure types of solids.					
2. Compare the different methods of materials synthesis.					
3. Apply composite materials for achieving required properties for different applications.					
4. Interpret the reason for functioning of a given material.					
5. Identify appropriate material for a given application in conducting, magnetic, optical, and dielectric applications.					
6. Build a device using suitable material for practical application					
Module:1	Symmetry and structural aspects of solids	9 hours			
Symmetry elements - point groups, space groups. Fundamentals and applications of X-ray diffraction, indexing of cubic system. AB <sub>2</sub> -pyrite, cuprite - A <sub>2</sub> B <sub>3</sub> - Al <sub>2</sub> O <sub>3</sub> (Corundum type) and rare- earth oxides, AB <sub>3</sub> - ReO <sub>3</sub> , pervoskites, K <sub>2</sub> NiF <sub>4</sub> , A <sub>2</sub> B <sub>2</sub> O <sub>7</sub> (pyrochlores), AB <sub>2</sub> O <sub>4</sub> (Spinel), Zeolites. Alloys-Cu-Ni, Cu-Zn, amorphous and glass materials.					
Module:2	Preparative Strategies Basics	6 hours			
Chemistry behind solid state synthesis – thermodynamic and kinetic aspects, phase transitions in solids. Techniques high temperature solid state synthesis- Co-precipitation, precursor, sol-gel, combustion, intercalation, chimie douce, ion-exchange, microwave, electrochemical, sonochemical, hydrothermal - High temperature and high-pressure synthesis.					
Module:3	Polymers and Composite Materials	6 hours			
Polymer structure - chain structure - micro structure - crystal structure crystallinity - determination of crystallinity, size and orientation of crystallites using X-Rays-conformation and configuration. Compositematerials - metal matrix, ceramic -matrix, polymers matrix - properties and applications.					
Module:4	Transport Properties	8 hours			
Non-stoichiometry: Preliminary aspects, Defects in solids: Stoichiometric and non-stoichiometric defects - point defects - Schottky and Frenkel defects and properties-color centers. Electronic conductors - metals, semiconductors, superconductors - Ionic conductors - fast ion conductors, solid electrolytes, mixed conductors-measurements - two and four probe measurements, impedance measurements.					
Module:5	Magnetic Properties	4 hours			
Magnetic properties- Dia, para, ferro, anti-ferro and ferri magnetism-spinels and garnets-measurements-magnetic moment and magnetic susceptibility.					

<b>Module:6</b>	<b>Optical and Dielectric Properties</b>	<b>6 hours</b>
Optical properties- Optical absorption and band gaps - luminescence- lasers: principle, characteristics and materials, Dielectric properties- ferro, anti-ferro, piezo and pyro electric properties- relationship and applications.		
<b>Module:7</b>	<b>Thermoelectric and Battery materials</b>	<b>4 hours</b>
Thermoelectric materials- intermetallics and oxides. Lithium battery materials - electrode and electrolyte materials. Solid Oxide Fuel Cells- material aspects.		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
<b>Text Book(s)</b>		
1.	Anthony R. West, Solid State Chemistry and its Applications, 2 <sup>nd</sup> Ed., John Wiley & Sons, 2014.	
2.	Bradley D. Fahlman, Materials Chemistry, 2 <sup>nd</sup> Ed., Springer, 2011.	
<b>Reference Books</b>		
1.	Lesley E. Smart and Elaine A. Moore, Solid State Chemistry-An Introduction, 4 <sup>th</sup> Ed., CRC Press,Taylor and Francis Group, 2012.	
2.	Richard J. D. Tilley, Understanding Solids: The Science of Materials, 2 <sup>nd</sup> Ed., Wiley, 2013.	
3.	Chawla K Krishnan, Composite Materials -Science and Engineering, Springer, 2012.	
4.	Robert J. Young and Peter A. Lovell, Introduction to Polymers, 3 <sup>rd</sup> Ed., CRC Press, 2011.	
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar		
Recommended by Board of Studies		26-02-2024
Approved by Academic Council		No. 73      Date      14-03-2024

Course Code	Course Title	L	T	P	C
PCHY616L	Nanomaterials and Characterization Techniques	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1.Understanding different types of nanomaterials, their syntheses and characterization					
2.Applying nanomaterials for technological applications					
Course Outcomes					
1. Define different types of nanomaterials based on dimensionality and structure.					
2. Propose preparation methods for different nanomaterials.					
3. Analyse nanomaterials using characterization techniques.					
4. Explain the structural and chemical properties of carbon-based nanomaterials.					
5. Propose nanomaterials for specific optical, electronic and energy storage applications.					
6. Relate structure of nanomaterials with their properties.					
Module:1	Zero-Dimensional Nanostructures	6 hours			
Quantum dots and hollow spheres: uniform and heterogeneous particle arrays, core-shell quantum dots and hollow spheres - synthesis and characteristics. LED, solar cell and laser applications.					
Module:2	One-Dimensional Nanostructures	6 hours			
Carbon nanotubes (CNTs), nanowires and nanofibers: synthesis and characteristics, functionalization of CNTs, role of 1D nanostructure as inter-connects in electronics.					
Module:3	Two-Dimensional Nanostructures	6 hours			
Thin films, nanosheets and nanodisks: preparation and characteristics, Role of a spin coater innanoscale film formation, 2D nanostructures as templates.					
Module:4	Three-Dimensional Nanostructures	6 hours			
Dendrites, nanopillers, nanoflowers and core-shell materials: preparation methods and characteristics, applications as catalysts and electrode material in batteries.					
Module:5	Energy Conversion and Storage Materials	6 hours			
Fuel cells: Hydrogen storage cells, Piezoelectric materials: principle and working mechanism. Fabrication of a piezoelectric sensor using electrospun nanofiber web.					
Module:6	Nanomaterials Characterization – 1	6 hours			
Powder X-Ray diffraction- peak broadening and particle size analysis, N <sub>2</sub> adsorption - surface area,pore size analysis, thermal analysis using TGA and DTA.					
Module:7	Nanomaterials Characterization – 2	7 hours			
UV-Vis spectroscopy- surface plasmon resonance, morphology and particle size analysis - SEM, AFM and HR-TEM, Raman spectroscopy – application for carbon nanomaterials.					
Module:8	Contemporary Issues	2 hours			
Industry Expert Lecture					
	Total Lecture hours:				45 hours

Text Book(s)			
1.	Nanomaterials: An Introduction to Synthesis, Properties and Applications, D. Vollath (Ed), 2 <sup>nd</sup> edition, Wiley VCH, 2013.		
2.	Nanomaterials, Nanotechnologies and Design, Michael F. Ashby, Paulo J. Ferreira and Daniel L. Schodek, Butterworth-Heinemann, 2009.		
3.	Textbook of Nanoscience and Nanotechnology, B.S. Murty , P. Shankar , Baldev Raj , B B Rath , James Murday, Universities Press (India) Pvt. Limited, 2013.		
Reference Books			
1.	Essentials in Nanoscience and Nanotechnology, Narendra Kumar, Sunita Kumbhat, John Wiley & Sons, Inc., 2016.		
2.	Materials Chemistry, Bradley D. Fahlman, 3 <sup>rd</sup> edition, Springer Nature B.V. 2018		
3.	Piezoelectric polymer and piezocapacitive nanoweb based sensors for monitoring vital signals and energy expenditure in smart textiles, J. Fiber Bioeng. Inform. 6, 369, 2013.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY617L	Inorganic Photochemistry	4	0	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1.Applying the principles of photochemistry in photosynthesis, solar energy conversion medical photochemistry. 2.Developing the devices based on photochemistry for solar energy conversion and medicalapplications.					
Course Outcomes					
1. Explain the mechanism of photochemical and photophysical processes. 2. Apply photophysical processes for versatile applications. 3. Analyze and interpret photoredox reactions. 4. Examine and classify photochemical reactions in coordination complexes. 5. Construct solar energy conversion devices. 6. Develop therapeutic techniques based on photochemical principles.					
Module:1	Photochemistry	5 hours			
Photochemical Vs Thermal reactions, Laws of photochemistry, Photophysical mechanism of excited states, Electronic Structure - Types of Excited States and Electronic Transitions - Absorption and Emission Bands - Jablonski Diagram, fluorescence, phosphorescence and delayed fluorescence, photosensitizers, chemiluminescence, bioluminescence internal conversion, intersystem crossing, Types of transitions in inorganic complexes.					
Module:2	Binuclear Photophysical Process	9 hours			
Quantum yields and experimental determination, numerical problems on quantum efficiency, Quenching of excited states, fluorescence life time, Stern-Volmer Equation, mechanism of quenching - heavy atom quenching, excimer and exciplex.					
Module:3	Applications of Photophysical and Photochemical Process	7 hours			
Characteristics and inorganic practical applications of fluorescence and phosphorescence, Photochemical Reactivity - Electrochemical Behavior - Polynuclear Metal Complexes, Explanation of incidents - Photosynthesis in plants, Photochemical smog, atmospheric ozone layer, vision by rhodopsin, formation of vitamin D in sunlight, photodegradation of plastics and organic pollutants.					
Module:4	Inorganic Photochemistry	8 hours			
Photoredox reactions of Cobalt(III), models of photoredox systems-radical pair model, photoredox reactions of Iron(III) complexes, photochemistry of metal-carbonyl complexes.					
Module:5	Ligand Field Photochemistry	9 hours			
Photosubstitution – photoisomerisation, photoracemization, photoaquation, rearrangement reactions Photochemistry of Chromium – photolysis rules – stereochemistry photoisomerisation photoracemization, Photonation, Photoactive excited states, Cobalt(III) complex in photosensitization.					
Module:6	Solar Energy Conversion	10 hours			



Solar energy conversion – Introduction to three generations of solar cells - photovoltaic p-n junctionsolar cell - importance of silicon - single crystal, polycrystal and amorphous - Si wafer preparation; Heterojunction – photoelectrochemical-liquid junction solar cell, multiple junction solar cell, dye- sensitized solar cell; Perovskite solar cells.			
<b>Module:7</b>	<b>Medical Photochemistry</b>		<b>10 hours</b>
Introduction, Cells, Tissues and Light, Historical aspects, importance and applications of Photosensitization, photophysics and photochemistry of PDT, Type I and Type II Mechanism, Singlet oxygen, Generations of PDT, Cancer photodetection, Porphyrin photosensitizers for PDT.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>60 hours</b>
<b>Text Book(s)</b>			
1.	Inorganic photochemistry, Julia A Wienstein, Springer, 2013.		
2.	Photochemistry of Transition Metal Complexes, Torn Bitterley, Elsevier, 2011.		
<b>Reference Books</b>			
1.	Applied photochemistry, Rachel C Evans, Peter Douglas, Hugh D Buren, Springer, 2013.		
2.	Photochemistry of Inorganic and Organometallic complexes, B.J. Palmer, Elsevier, 2012.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY618P	Inorganic Chemistry Specialization Lab II	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Training the students in synthesis of inorganic complexes and materials.					
2. Acquainting chemical and instrumental methods of analysis of inorganic complexes and materials					
Course Outcomes					
1. Make use of synthesis methodologies to make inorganic complexes.					
2. Apply the different methods of material synthesis to prepare oxides.					
3. Relate the principle of redox chemistry in intercalation reactions.					
4. Analyze the prepared materials using chemical and instrumental analytical techniques.					
Indicative Experiments					
1.	I. Preparation and Analysis of Complexes (UV-Visible and FTIR) Metal Analysis: 1. Chloropentaamminecobalt (III) chloride, [Co(NH <sub>3</sub> ) <sub>5</sub> Cl]Cl <sub>2</sub> 2. Trithiourea zinc(II)sulphate, Zn(SC(NH <sub>3</sub> ) <sub>2</sub> ) <sub>3</sub> OSO <sub>3</sub> 3. Potassium bisoxalatocuprate(II)dihydrate, K <sub>2</sub> [Cu(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ]. 2H <sub>2</sub> O 4. Molar conductance of [Co(NH <sub>3</sub> ) <sub>6</sub> ]Cl <sub>3</sub> and [Co(NH <sub>3</sub> ) <sub>5</sub> Cl]Cl <sub>2</sub>				24 hours
2.	II. Synthesis of Oxides (Phase purity check by powder XRD): 1. CaMnO <sub>3</sub> by ceramic method 2. BaTiO <sub>3</sub> by sol-gel method 3. SnO <sub>2</sub> by precipitation method 4. Ruby by combustion method				24 hours
3.	III. Simple Redox Reactions 1. Hydrogen intercalation in tungsten trioxide				8 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas, John Wiley & Sons, Inc., 2015.				
2.	Practical Inorganic Chemistry - Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer, 2013.				
Reference Books					
1.	Handbook on Synthesis Strategies for Advanced Materials, Volume-I: Techniques and Fundamentals, A. K. Tyagi, Raghumani, S. Ningthoujam, Springer Nature Singapore Pte. Ltd., 2022.				
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT					
Recommended by Board of Studies			26-02-2024		
Approved by Academic Council			No. 73	Date	14-03-2024

Course Code	Course Title	L	T	P	C
PCHY619P	Inorganic Chemistry Specialization Lab III	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Training in synthesis of inorganic material, characterization and chemical analysis 2. Understanding the importance of different instrumental methods in chemical analysis of materials.					
Course Outcomes					
1. Understand the principle of powder X-ray diffraction technique. 2. Illustrate the basic concepts of various physical properties. 3. Apply powder X-ray diffraction technique for materials analysis. 4. Evaluate structure property relationship of materials.					
Indicative Experiments					
I.	I. Applications of powder X-ray diffraction 1. Analysis of XRD data of inorganic material i) Phase identification ii) Latitce parameters calculation and indexing iii) Theoretical Density calculation from XRD				16 hours
	2. Vegard's law verification and crystallite size calculation i) Verification of Vegard's law a. Ba <sub>1-x</sub> Sr <sub>x</sub> TiO <sub>3</sub> b. Ca <sub>1-x</sub> Sr <sub>x</sub> TiO <sub>3</sub> ii) Crystallite size calculation using Scherrer formula				16 hours
II.	II. Physical property measurements 1. Resistivity measurement - Four probe method - Si band gap 2. Determination of magnetic parameters using Hysteresis Loop 3. Photocatalysis (dye degradation) 4. Measurement of dielectric constant 5. Oxide Semiconductor band gap - DRS - Tauc's plot				28 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	X-Ray Diffraction - A Practical Approach, C. Suryanarayana, M. Grant Norton, Springer NY, 2013.				
Reference Books					
1.	Practical Inorganic Chemistry - Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer, 2013.				
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT					
Recommended by Board of Studies			26-02-2024		
Approved by Academic Council			No. 73	Date	14-03-2024

Course Code	Course Title	L	T	P	C
PCHY620L	Process Chemistry in Pharmaceutical Industry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Gaining the knowledge of process chemistry in pharmaceutical industry					
2. Understanding scale up of process in pharmaceutical industry.					
3. Developing the skills to improve the existing methods into cost effective green methods					
Course Outcomes					
1. Recall the importance of process chemistry.					
2. Explain the role of solvents and importance of solvent free reactions in process industry.					
3. Assess the reaction conditions in laboratory and its scale up in process industry					
4. Outline safety in process industry, including catalyst selection and impurity minimization.					
5. Appraise and validate of scale up process and finished products.					
6. Propose process scale up process for reactions and tools for purification of finished product.					
Module:1	Introductory level of Process Chemistry	6 hours			
Introduction to process chemistry approaches to process development, Principle of process development, Route Selection, expedient and cost-effective routes, Reagent selection, solvent selection, alternatives to solvents, Water as as a solvent. Various examples of reactions regularlyperformed in process chemistry lab.					
Module:2	Selection of Solvents and solvent free reactions	6 hours			
Running the reaction, assessing operating conditions for the laboratory, reaction scale selection, selection of reaction conditions, Example of various name reaction and their selection is processchemistry lab.					
Module:3	Selection of Reactions	6 hours			
Running the reaction, assessing operating conditions for the laboratory, reaction scale selection,selection of reaction conditions.					
Module:4	Industrial Safety Studies	6 hours			
Purification of products; tools and techniques - crystallization and reslurrying, final product form, polymorphs. Validation of finished products, Various purification techniques – Solvent washing, HPLC (use of chiral column), Column Chromatography, Plate layer Column chromatography.					
Module:5	In Process Control (IPC)	6 hours			
In process control (IPC) - importance, selection of IPC, Reproducible IPC, optimization by minimizing impurities, optimization of catalytic reaction, work up of reaction.					
Module:6	Purification Tools and Identification Techniques	6 hours			
Purification of products; tools and techniques - crystallization, chromatographic separation, reslurrying, final product form, polymorphs, Identification of Finished					

product by instrumental techniques.			
<b>Module:7</b>	<b>Scale Up Process and validation of Finished products</b>		<b>7 hours</b>
Batch reactions, Continuous and Semi-continuous reactions, Continuous reactors to scale up of the process- Static mixers, plug flow reactors, microwave reactors, Sonochemical reactors. Validation as per ICH, EMEA and FDA guidelines			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
	<b>Total Tutorial hours:</b>		<b>15 hours</b>
<b>Text Book(s)</b>			
1.	Practical Process research and Development, Neal G. Anderson 2 <sup>nd</sup> Edition, Academic Press, 2012.		
2.	Fundamentals of Analytical Chemistry, Douglas A Skoog, Donald M West, F James Holler, Stanley R. Crouch, 9th Edition, Wadsworth Publishing Co Inc., 2012.		
<b>Reference Books</b>			
1.	The Art of Drug Synthesis, Douglas S. Johnson, Jie Jack Li, John Wiley and Sons, 2013.		
2.	Green Chemistry in the Pharmaceutical Industry, Peter J. Dunn, Andrew Wells, Michael T. Williams, John Wiley & Sons, 2010.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY621L	Pharmacognosy and Phytochemistry	3	1	0	4
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1.Acquainting biological functions and pharmacological uses of natural products. 2.Recognizing primary and secondary metabolites and their sources 3.Understanding the concepts of isolation methods and separation of bioactive compounds. 4.Learning pharmacognostical analysis of the bioactive compounds					
Course Outcomes					
1.Recall the sources of natural medicines and analysis of crude drugs. 2.Define methods of evaluation of natural products based on various parameters. 3.Analyze the isolated drugs as per ICH guidelines. 4.Apply techniques to discover new alternative medicines. 5.Evaluate the isolated drugs for various pharmacological activities. 6.Propose methods to synthesize new drugs based on natural/isolated drugs.					
Module:1	Pharmacognosy	6 hours			
Introduction, definition, history, scope, development and classification; Source of Drugs: Biological, marine, mineral and plant tissue cultures as source of drug. Scheme of pharmacognostic studies of a crude drug. Biosynthesis: Shikimic acid pathway and acetate pathway. Systematic analysis of Crudedrugs.					
Module:2	Standardization of herbal drugs	6 hours			
WHO guidelines, Sampling of crude drug, Methods of drug evaluation. Determination of foreign matter, moisture, LOD, Ash value. Extractable values, Determination of swelling index, foaming index and their significance. Phytochemical investigations: General chemical tests.					
Module:3	Extraction techniques	6 hours			
General methods of extraction, types – maceration, Decoction, percolation, Immersion and Soxhlet extraction. Advanced techniques- counter current, steam distillation, supercritical gases, sonication, microwaves assisted extraction. Factors affecting the choice of extraction process					
Module:4	Drugs containing terpenoids and volatile oils	6 hours			
Terpenoids: Classification, Isoprene rule, Isolation and separation techniques, General properties Camphor, Menthol, Eucalyptol. Volatile Oils or Essential Oils: Method of Preparations, Classifications of Volatile oils, Camphor oil, Geranium oil, Citral- Structure, uses. Pentacyclic triterpenoids: amyrines; taraxasterol: Structure and pharmacological applications.					
Module:5	Drugs containing alkaloids	5 hours			
Occurrence, function of alkaloids in plants, pharmaceutical applications. Isolation Qualitative tests and general properties. General methods of structural elucidation. Morphine, Reserpine, Papaverine-structure, chemical properties and uses.					
Module:6	Plant glycosides	9 hours			
Glycosides: Basic ring system, classification, isolation, properties, qualitative					

analysis. Pharmacological activity of Senna glycosides, Cardiac glycosides-Digoxin, digitoxin, strophanthidin, Steroidal saponins glycosides- Diosgenin, hecogenin. Plant pigments: Occurrence, nomenclature, and general methods of structure determination, isolation and synthesis of quercetin and cyanidin.			
<b>Module:7</b>	<b>Marine drugs</b>		<b>5 hours</b>
Selected Drug Molecules: Cardiovascular active substances, Cytotoxic compounds, antimicrobial compounds, Antibiotic compounds, Anti-inflammatory agents. Marine toxins.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
	<b>Total Tutorial hours:</b>		<b>15 hours</b>
<b>Text Book(s)</b>			
1.	Gurdeep R Chatwal (2016), Organic chemistry of Natural products, Volume I&II, 5 <sup>th</sup> edition,Himalaya publishing House.		
2.	S.V.Bhat, B.A. Nagasampagi, M.Sivakumar (2014), Chemistry of Natural Products, Revisededition, Narosa Publishers.		
<b>Reference Books</b>			
1.	Jeffrey B. Harborne (2012), Phytochemical methods: A Guide to Modern Techniques of PlantAnalysis, 4 <sup>th</sup> edition, Indian reprint, Springer.		
2.	Ashutoshkar (2007), Pharmacognosy and Pharmacobiotechnology, 2 <sup>nd</sup> edition, New ageinternational (P) limited, New Delhi.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY621P	Pharmacognosy and Phytochemistry Lab	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Learning the chemistry behind development and activity of pharmaceuticals. 2. Gaining the knowledge of mechanism of action and adverse effects of drugs. 3. Understanding the need of judicious usage of antibiotics.					
Course Outcomes					
1. Analyze composition and importance of phytoconstituents. 2. Apply the skill of extraction and isolation of phytoconstituents. 3. Assess the purity of the extracted or isolated phytoconstituents. 4. Estimate various parameters of isolated drugs and check the standards as per ICH guidelines.					
Indicative Experiments					
1.	Extraction, Isolation and Characterization (UV/IR/NMR/MS) of the following the phytoconstituents from the Natural products				6 hours
2.	Starch from Potatoes				6 hours
3.	Caffeine from Tea Leaves/Tea Dust Powder				6 hours
4.	Lycopene from Tomato				6 hours
5.	Lawsonine from Henna Powder/Leaves				6 hours
6.	Curcumin from Turmeric Powder				6 hours
7.	Extraction and detection of volatile oils by Clevenger's Method (Hydro-distillation method).				4 hours
8.	Determination of Extractive Values of some crude Drugs.				4 hours
9.	Determination of Extractive Values of some crude Drugs.				4 hours
10.	Estimation of Caffeine from Tea by Spectrophotometric/HPTLC Method				4 hours
11.	Determination of Saponification and Acid value of the Fat and Oils by taking any real sample				4 hours
12.	Estimation of Ascorbic acid from Citrus Fruits (Vitamin C)				4 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Practical Pharmacognosy and Phytochemistry, Sushilkumar A. Shinde, N. M. Bhopale, 1st Edition, Vallabh Prakashan Publisher, 2023.				
2.	Practical Pharmacognosy, Techniques and Experiment, Khandelwal K. R, Nirali Prakashan, 2006.				
Reference Books					
1.	Phytochemical Methods: A Guide to Modern techniques of Plant Analysis, Jeffrey B. Harborne, 4th Edition, Indian Reprint, Springer, 2012.				



2.	Natural Products: A Laboratory Guide, Raphael and Ikan, 2nd Edition, Academic Press, 2013.		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY622L	Pharmaceutical Quality Control and Quality Assurance	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1.Ascertaining the quality of the finished pharmaceutical product and its validation to facilitate its market launch.					
2.Gaining the knowledge about ICH guidelines, i.e., the organization that sets and governs the laws and rules for all the quality tests.					
3.Controlling the quality of the formulation and assuring the compliance of standards.					
Course Outcomes					
1. Recall the importance and methods of quality assurance in the pharmaceutical industry.					
2. Outline auditing, quality of auditing, and personal responsibilities involved in quality control of an organization.					
3. Analyze the documentations associated with manufacturing, master formula, distribution, returned goods and recovered materials.					
4. Apply validation process at different levels, including personal, equipment, and regulatory aspects.					
5. Evaluate the quality process and factors influencing the stability of products, and quality of packaging materials.					
6. Propose quality assurance and control measures for documentation based on regulations in pharmaceutical industry.					
Module:1	Concept and Philosophy	7 hours			
Total Quality Management (TQM), Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP).					
Module:2	Quality Audit	6 hours			
Quality audit, Standard Operating Procedure (SOP), International Conference Harmonization (ICH), ISO-9000, ISO14000, WHO specifications, USFDA guidelines and ICMR.					
Module:3	Organization and personnel responsibilities	6 hours			
Training, Hygiene, Premises: Location, Design, Plant layout, Construction, Maintenance and Sanitations. Environmental control, Sterile areas, control of contamination.					
Module:4	Documentation & Handling	5 hours			
Manufacturing documents, Master Formula, batch formula Record, Distribution of records, Handling of returned goods, Recovered materials and Reprocessing.					
Module:5	Regulatory aspects of Pharmaceuticals	7 hours			
Validation of Personnel, Equipment and Cleaning methods, Regulatory aspects of pharmaceuticals New Drug Approval Process: Investigational New Drug (IND), New Drug Applications (NDA) and its approval, Drugs and Cosmetic Act, Patent Regime.					
Module:6	Quality process	7 hours			
In-process quality control on various dosage forms, Sterile and non- sterile					

operations. Factors affecting stability of formulations and shelf – life prediction, techniques to determine and improve shelf life.			
<b>Module:7</b>	<b>Quality control of packaging materials</b>		<b>5 hours</b>
Types of plastics, primary and secondary packaging materials (glass, closures, cartons, blister andtheir control).			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Quality Assurance of Aseptic Preparation Services: Standards Part A, 5 <sup>th</sup> edition, Alison M Beaney, Royal Pharmaceutical Society and the NHS Pharmaceutical Quality Assurance Committee, 2016.		
2.	Managing for quality and performance excellence ninth edition James R. Every, WilliamM.Lindsay South-western Cengage learning, 2014.		
<b>Reference Books</b>			
1.	Sed mtiazhaider. (2011), Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA		
2.	Ira R. Berry, Robert A Nash (2013), Pharmaceutical process validation, 3rd Rev Edition, Marcel Dekker.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY623L	Medicinal Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding the chemistry behind the development and activity of pharmaceutical materials.					
2. Imparting the knowledge of mechanism of action and adverse effects of drugs.					
3. Acquainting the mechanism of action of antibiotics and their adverse effects upon erratic usage.					
Course Outcomes					
1. Relate drug's properties with its structure.					
2. Explain the factors affecting absorption, distribution, metabolism, and excretion of drugs and hence the considerations to be made in drug design.					
3. Outline the relationship between drug's chemical structure and therapeutic properties.					
4. Apply the knowledge of different theories of drug actions at molecular level to identifydifferent targets for the development of new drugs					
Module:1	Introduction to receptors	6 hours			
Introduction, targets, Agonist, antagonist, partial agonist.Receptors, Receptor types, Theories of Drug -receptor interaction, Drug synergism, Drug resistance, physicochemical factors influencingdrug action. Isosterism and bioisosterism					
Module:2	Antibiotics	9 hours			
Introduction, Targets of antibiotics action, classification of antibiotics, enzyme-based mechanism of action, SAR of penicillins and tetracyclins, clinical application of penicillins, cephalosporin, Beta lactamase inhibitors, tetracyclines, Current trends in antibiotic therapy.					
Module:3	Antihypertensive agents and diuretics	6 hours			
Classification of cardiovascular agents, introduction to hypertension, etiology, types, classification of antihypertensive agents, classification and mechanism of action of diuretics, Furosemide,Hydrochlorothiazide, Amiloride.					
Module:4	Drugs for Tuberculosis	5 hours			
Classification, mechanism of action of drugs employed for the treatment of Tuberculosis Currenttreatment strategy for tuberculosis.					
Module:5	Analgesics, Antipyretics and Anti-inflammatory Drugs	6 hours			
Introduction, Mechanism of inflammation, classification and mechanism of action of NSAIDs and SAR of paracetamol, Ibuprofen, Diclofenac, naproxen, indomethacin, phenylbutazone andmeperidine					
Module:6	Medicinal Chemistry of Antidiabetic Agents	6 hours			
Introduction, Types of diabetics, Drugs used for the treatment, chemical classification, SAR, Mechanism of action, Study the treatment strategy of diabetic mellitus. Chemistry of insulin, sulfonyl ureas					
Module:7	Drugs for malaria	5 hours			
Classification, mechanism of action of drugs employed for the treatment of					

malaria. Current treatment strategy for malaria.			
<b>Module:8</b>		<b>Contemporary Issues</b>	
Industry Expert Lecture		<b>2 hours</b>	
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Wilson and Gisvold's textbook of organic medicinal and pharmaceutical chemistry, Wilson, Charles Owens,;Beale, John Marlowe ;Block, John H, Lipincott William, 12 <sup>th</sup> edition, 2011.		
2.	An Introduction to Medicinal Chemistry - Graham L. Patrick, 5 <sup>th</sup> edition, Oxford University Press, 2013.		
<b>Reference Books</b>			
1.	Foye's Principles of Medicinal Chemistry, Lipincott Williams, Seventh Edition, 2012		
2.	Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic press, 2010.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY623P	Medicinal Chemistry Lab	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
Acquiring hands on training in synthesis of some drug molecules and estimation of parameters related to drug designing.					
Course Outcomes					
1. Understand the practical aspects of drug synthesis. 2. Learn the skill to synthesize and purify the drug molecules. 3. Assess the quality of the commercial product as per standard procedures like ICH guidelines. 4. Learn the analytical techniques to estimate various parameters related to drug designing					
Indicative Experiments					
1.	Synthesis of medicinally active compounds (Any two) from the following given compounds- Phenytoin, Benzocaine, Barbituric acid and Phenothiazine.				6 hours
2.	Synthesis of medicinally active compound; Phenytoin from benzoin- Step One: Benzoin to Benzil				6 hours
3.	Synthesis of medicinally active compound: Phenytoin spectroscopic methods				6 hours
4.	Synthesis of medicinally active compounds - Benzocaine Step One: p-nitrobenzoic acid to p-amino benzoic acid				6 hours
5.	Synthesis of medicinally active compounds – Benzocaine Step Two: p-amino benzoic acid to Benzocaine Purification by column, crystallization, Characterization by spectroscopic methods				6 hours
6.	Quantification of active substance in commercial products: Assay of Isoniazid Tablets IP				6 hours
7.	Quantification of active substance in commercial products: Assay of Paracetamol Tablets IP				4 hours
8.	Quantification of active substance in commercial products: Assay of Aspirin Tablets IP				4 hours
9.	Quantification of active substance in commercial products- Assay of Sulphanilamide Tablets IP				4 hours
10.	Quantification of active substance in commercial products- Assay of Chloramphenicol Capsules IP				4 hours
11.	Substituent effects of groups in medicinally active molecules				4 hours
12.	In vitro antioxidant studies by hydrogen peroxide method				4 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Vogel text book of practical organic chemistry, Brian S. Furniss, Antony J.				

	Hannaford, Peter W. G. Smith, Austin R. Tatchell, 5 <sup>th</sup> Edition, Longman Scientific & Technical Publishers Ltd., 2011.		
2.	Indian Pharmacopoeia 1996, The Controller of Publications, Civil Lines, Delhi - 110054.		
Reference Books			
1.	Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic press, 2010.		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY624L	Advanced Physical Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding thermodynamics of chemical equilibrium, kinetics of fast reactions and electrode kinetics.					
2. Enriching knowledge about photoinduced electron transfer and photocatalytic reactions.					
3. Understanding the principles and applications statistical thermodynamics.					
4. Getting insight into electric properties of molecules and their interactions.					
Course Outcomes					
1. Evaluate the thermodynamics of equilibrium and relationship between equilibrium with temperature and pressure.					
2. Analyze the kinetics of fast reactions using instrumentation techniques.					
3. Apply theories in electrochemistry to analyze electrode kinetics through Butler-Volmer andTafel equations.					
4. Explain photoinduced electron transfer and analyze photocatalytic reactions includinghydrogen generation reactions.					
5. Analyze most probable distributions of a system among the energy levels using the principles of statistical thermodynamics.					
6. Summarize Boltzmann, Bose-Einstein and Fermi-Dirac statistics and evaluate different partitionfunctions for diatomic molecules.					
7. Analyze the electric properties of molecules and their interactions.					
Module:1	Chemical Equilibrium	7 hours			
Spontaneous chemical reactions: The Gibb's energy minimum – a) reaction Gibbs energy, b) Exergonic and endergonic reactions; Description of equilibrium – a) Perfect gas equilibria, b) The general case of a reaction, c) calculation of equilibrium constant, d) The relation between equilibrium constants, e) Molecular interpretation of the equilibrium constant, f) Equilibria in biological systems; Response of equilibria to conditions: Change in equilibria with changes in pressure, temperature; Value of equilibrium constant at different temperatures.					
Module:2	Chemical Kinetics-II	5 hours			
Study of kinetics of fast reactions-stopped flow technique, relaxation method, processinstrumentation, methodologies and applications.					
Module:3	Electrochemistry-II	5 hours			
Electrical Double layer: Theories of Double-Layer structure, diffuse-double-layer theory of Gouyand Chapman, the Stern Model; electrode kinetics-derivation of the fundamental equation of electrode kinetics. Butler-Volmer equation-low field and high field approximations-Tafelequation.					
Module:4	Photophysical Chemistry II	7 hours			
Photoinduced electron transfer: Reaction rates, free energy dependence of electron transfer on rate, Photoinduced energy transfer - FRET, rate and efficiency					



calculation of FRET - Absorption of light and nature of electronic spectra. Semiconductor as photo catalysts in photolysis reactions: Generation of hydrogen by photo catalysts - photo catalytic break down of water and harnessing solar energy - photocatalytic degradation of dyes - environmental applications.			
<b>Module:5</b>	<b>Statistical Thermodynamics I</b>		<b>6 hours</b>
Concepts of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical and microcanonical ensembles.			
<b>Module:6</b>	<b>Statistical Thermodynamics II</b>		<b>6 hours</b>
Thermodynamics and entropy, Maxwell - Boltzmann, Bose - Einstein and Fermi - Dirac statistics, partition function - rotational, translational, vibrational and electronic partition functions for diatomic molecules. Heat capacity of solids.			
<b>Module:7</b>	<b>Molecular Interactions</b>		<b>7 hours</b>
Electric Properties of molecules - Electric dipole moments, Polarizabilities, Polarization, Relative permittivities; Interactions between molecules: Interactions between dipoles – a) Potential energy interaction, b) Dipole-dipole interaction, c) Dipole-induced-dipole interactions, d) Induced-dipole-induced-dipole interactions, e) hydrogen bonding, f) hydrophobic interaction g) Repulsive and total interactions.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industry Expert Lecture			
<b>Total Lecture hours:</b>			<b>45 hours</b>
<b>Text Book(s)</b>			
1.	P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, 2018, International 11th Edition, Oxford University Press, United Kingdom.		
2.	B. R. Puri, L. R. Sharma, M. S. Pathania, principles of physical chemistry, 47 <sup>th</sup> Edition, Vishal Publishing Co., 2017.		
3.	Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, John Wiley and Sons Inc. 2001.		
<b>Reference Books</b>			
1.	N. Levine, Physical Chemistry, 6 <sup>th</sup> Edition, McGraw Hill, New York, 2011.		
2.	K. J. Laidler, Chemical Kinetics, 3 <sup>rd</sup> Edition, Harper & Row, New York, 2013.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY625P	General Organic and Inorganic Chemistry Lab	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Imparting skills in synthesis of organic molecules and inorganic complexes & materials.					
2. Analyzing the synthesized materials using instrumental methods of chemical analysis.					
Course Outcomes					
1. Estimate the given organic compounds using quantitative analysis.					
2. Make use of synthesis methodologies for drug molecules and inorganic complexes.					
3. Demonstrate extraction of natural products.					
4. Apply preparation methods for getting the given inorganic oxides of importance.					
5. Evaluate the products obtained using characterization techniques.					
Indicative Experiments					
1.	Estimation of the following: a) Estimation of Glucose b) Estimation of Methyl Ketone				12 hours
2.	Synthesis of the following drug molecules: a) Synthesis of phenytoin b) Synthesis of 2,3-diphenyl quinoxaline c) Synthesis of 2-phenylindole				12 hours
3.	Extraction of natural products: a) Caffeine from Tea leaves b) Piperine from Black pepper				12 hours
4.	Coordination Complexes: a) Preparation of Chloropentaammine cobalt(III) chloride, [Co(NH3)5Cl]Cl2 b) Preparation of Potassium bisoxalatocuprate(II)dihydrate, K2[Cu(C2O4)2].2H2O				12 hours
5.	Synthesis of oxides: a) YBa2Cu3O7 by ceramic method b) SnO2 by precipitation method c) Ruby by combustion method				12 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Comprehensive practical organic chemistry, V.K. Ahluwalia and R. Aggarwal, University press, 2000.				
2.	Practical Inorganic Chemistry - Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer, 2013.				

3.	Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas, John Wiley & Sons, Inc., 2015.		
Reference Books			
1.	Vogel's Quantitative Chemical Analysis, Arthur Israel Vogel, J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, R. C. Denney, and M. J.K. Thomas 6th Edition, Prentice Hall, 2000.		
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY626P	Analytical Chemistry Lab I	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
The courses is aimed at Imparting the training in operating different instruments used in the analysis of various chemical constituents.					
Course Outcomes					
1. Design chromatographic and titrimetric methods for identification of species. 2. Analyse different constituents through instrumental methods of analysis 3. Evaluate different contaminants in materials using turbidimetry and conductivity measurements					
Indicative Experiments					
1.	Determination of chloride by precipitation titration using conductometry.				10 hours
2.	Estimation of phosphate in waste water using colorimetry.				10 hours
3.	Extraction and iodometric estimation of copper in different alloys.				10 hours
4.	Estimation of Fe(II) by 1,10 phenonthroline using spectrophotometry.				10 hours
5.	Determination of Sulphate Ion by Turbidimetry				10 hours
6.	Decomposition of Diacetone alcohol - Dilatometry method.				10 hours
7.	Determination of specific rotation by polarimetry- Kinetics of inversion of sucrose in normal sugar and refined sugar samples.				10 hours
8.	Determination of solubility product by potentiometry - concentration cell				10 hours
9.	Gas chromatography assay of flavour chemicals.				10 hours
10.	Characterization of Functional Groups using IR Spectroscopy.				10 hours
Total Laboratory Hours					60 hours
Text Book(s)					
1.	Advanced Physical Chemistry Practical Guide, Charu Arora, Sumantra Bhattacharya, Bentham Science Publishers, 2022.				
2.	Kissinger, Laboratory Techniques in Electroanalytical Chemistry, Second edition, CRC Press, 2016.				
Reference Books					
1.	R. Holze, Experimental Electrochemistry: A Laboratory Textbook, Second edition, Wiley-VCH, 2019.				
Mode of Evaluation: CAT, Written Assignment, Quiz, and FAT					
Recommended by Board of Studies			26-02-2024		
Approved by Academic Council			No. 73	Date	14-03-2024

**Open Elective**

Course Code	Course Title	L	T	P	C
PCHY627L	Drug Design	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Familiarizing principles and applications of drug design and development. 2. Acquainting computational skills for understanding mechanism, interaction forces in drug actions and quantitative measurement of biological responses.					
Course Outcomes					
1. Demonstrate the steps involved in the drug discovery and design process. 2. Summarize the screening methods in the design of drugs. 3. Predict the functional groups involved in drug action and modifications required for a betterbiological response. 4. Choose ideal targets in drug design. 5. Outline pharmacophore and perform conformational searching. 6. Evaluate and formulate various QSAR models.					
Module:1	Fundamentals of drug design	7 hours			
Introduction, Drugs, agonist, antagonist, inhibitors-different types, lead molecule, lead discovery, random screening, non-random screening, Drug metabolism studies, clinical observations, drug targeting without lead, natural products as lead molecules, existing drugs as lead. Drug-Likeness and other compound filter mechanism					
Module:2	Lead Modification	6 hours			
Identification of the active site, pharmacophore, functional group modification, SAR, Scaffolds, Drug like molecules, Modifications- Homologation, chain elongation/branching, ring chain transformation, bioisosterims, Fragmentation of structures, Stereochemistry and Drug Action					
Module:3	Targets in drug Design	6 hours			
Targets in drug design: various targets in drug action, Species-specific genes as drug targets, membrane drug targets, RNA, DNA, Proteins validation of the targets, evaluating a structure forstructure based drug design.					
Module:4	Pharmacophore and pharmacophore mapping	6 hours			
Pharmacophore, 2D pharmacophore, 3D pharmacophore, Data bases (Cambridge, PDB) searching, conformational search, random conformational search, methods to derivepharmacophore, Pharmacophore Mapping.					
Module:5	Molecular interaction	6 hours			
Concept of Virtual screening, Structure-Based Virtual Screening ( <i>in silico</i> ), Protein-Ligand Docking, Scoring Functions for Protein-Ligand Docking, Practical Aspects of Structure-Based Virtual Screening, The Prediction of ADMET, Properties, Toxicity Prediction.					
Module:6	Molecular descriptors	6 hours			
Lipophilicity parameters, Measurement of partition coefficient and related parameters, Calculation of partition coefficient, electronic parameters, Steric parameters, Polarizability, parameters, Indicator variables, Other parameters					

involved topological features			
<b>Module:7</b>	<b>Basics of Quantitative Models in QSAR Approaches</b>		<b>6 hours</b>
Hansch Analysis, Free Wilson analysis, The Relationships between Hansch and Free Wilson Analysis, Nonlinear relationship, Dissociation and Ionization of Acids and Bases, Other QSAR Approaches, Applications of Hansch analysis, Free Wilson analysis.			
<b>Module:8</b>	<b>Contemporary Issues</b>		<b>2 hours</b>
Industrial invited lectures on Molecular modelling, Tools involved in molecular modelling and bioinformatics. Methods involved in drug Design.			
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Textbook of Drug Design and Discovery, Kristian Stromgaard, Povl Krogsgaard-Larsen, 4 <sup>th</sup> Edition, CRC Press, 2010.		
2.	The organic chemistry of drug design and drug action, Richard B Silverman, 3 <sup>rd</sup> edition, Elsevier Publishers, 2014.		
3.	QSAR: Hansch Analysis and Related Approaches, Vol.1, Hugo Kubinyi, VCH Publishers, 2006.		
<b>Reference Books</b>			
1.	Drug Design: Structure- and Ligand- Based Approaches, Kenneth M. Merz, Jr, Dagmar Ringe, Charles H. Reynolds, Cambridge University Press, 2010.		
2.	Textbook of Drug Design and Discovery, Tommy Liljefors, Povl Krogsgaard-Larsen, Ulf Madsen, 3 <sup>rd</sup> edition, CRC Press, 2006.		
3.	Recent Advances in QSAR Studies: Methods and Applications, Tomasz Puzyn, Jerzy Leszczynski, Mark T. Cronin, Springer, 2010.		
4.	Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic press, 2010		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY628L	Polymer Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding the basic concepts about polymers/macromolecules and polymerization techniques					
2. Knowing structure of polymers, tacticity and reactivity ratios.					
3. Make use of instrumental techniques for characterizing polymers					
Course Outcomes					
1. Recall the importance of macromolecules/polymers in day-to-day life and sustainable development.					
2. Apply instrumental techniques for polymer characterization.					
3. Develop macromolecules for specific applications and requirements in industry.					
Module:1	Concept of Polymer	7 hours			
Definition, nomenclature, Molecular weight (Mn, Mw), PDI. DP, Tg, Tm. Polymerization Techniques: Bulk, Suspension, Emulsion Polymerization and Interfacial Polycondensation					
Module:2	Chain Polymerization	8 hours			
Radical, cationic, anionic and coordination polymerization (Initiation – propagation – transfer- termination- processing kinetics – termination - living / controlled), Metathesis polymerization, metallocene and Non-metallocene Step Polymerization: Functionality monomers (monomers of type (XX + YY), XY type monomers, monomers of type (XX + YYY), examples)					
Module:3	Characterization	6 hours			
Methods for the characterization of Polymers: Molecular weight (Mn, Mw) and Polydispersity index (PDI) By size exclusion chromatography (GPC), Chain end analysis, Thermal analysis of polymers by DSC, TGA, TGDTA. Determination of branching					
Module:4	Stereoselectivity in polymers	5 hours			
Stereospecific polymerization: Stereoselective polymerization using single-site catalysts.					
Module:5	Evolution in polymer chemistry	5 hours			
From multisite to single site polymerization. Metathesis polymerization, ROP (ring opening polymerization).					
Module:6	Controlled/Living polymerization	7 hours			
Polymerization techniques such as NMP (nitroxyl mediated polymerization), GTP (group transfer polymerization), ATRP (atom transfer radical polymerization), RAFT (reversible addition fragmentation and chain transfer polymerization), metallocene and non-metallocene polymerization techniques					
Module:7	Copolymers	5 hours			
Block copolymers, alternative and random block copolymers. Reactivity ratios. Synthesis-Applications					
Module:8	Contemporary Issues	2 hours			



Industry Expert Lecture			
	Total Lecture hours:		45 hours
Text Book(s)			
1.	Principles of Polymerization, George Odian, 4th Edition, Wiley, 2004.		
2.	Polymer Science and Technology, Joel R. Fried, 3 <sup>rd</sup> Edition, Prentice Hall, 2014.		
Reference Books			
1.	High Performance Polymers, Johannes Karl Fink, 2 <sup>nd</sup> Edition, Elsevier, 2014.		
2.	Handbook of Polymer Synthesis, Characterization, and Processing, Enrique Saldivar-Guerra and Eduardo Vivaldo-Lima, Wiley-Blackwell, 2013.		
3.	Applications of Ionic Liquids in Polymer Science and Technology, David Mecerreyes, <del>Springer</del> , 2015.		
4.	Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, Manas Chanda, 2 <sup>nd</sup> Edition, CRC Press, 2013.		
5.	Chemical and physical chemistry of polymers, M. Fontanille and Y. Gnanou, Wiley, 2008.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY629L	Biophysical Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding the fundamental principles and underlying interplay between physical phenomena and the physical properties of biomolecules.					
2. Imparting knowledge on application of biophysical techniques and macromolecular analysis.					
3. Performing biochemical assays using various biophysical methods.					
Course Outcomes					
1. Recall characteristics and classifications of amino acids.					
2. Outline the methods of quantitative and qualitative analysis of biological molecules.					
3. Explain protein-protein and protein-nucleic acid interactions.					
Module:1	Intermolecular interactions	7 hours			
Hydrogen bonding, hydrophobic interactions and water as universal solvent in biological systems; Disruption of hydrophobic interactions by urea and other denaturants; Ionic interactions, hydrophobic versus ionic interactions; Disulfide bond, formation of specific disulfide link.					
Module:2	Structure of biomolecules	8 hours			
Conformational properties of amino acids and peptides; Primary, secondary, tertiary and quaternary structures; Structural features and prediction of protein structures; Structural features of nucleic acids- Ramachandran plot, Central Dogma (DNA → RNA → Protein).					
Module:3	Thermodynamics of biomolecules	5 hours			
Two state model of protein stability, chemical denaturation and stabilization, surface denaturation; Principles of ionization equilibrium ionization of side chain, equilibria in proteins.					
Module:4	Properties of Amino Acids	7 hours			
Predicting properties from amino acid composition, unusual amino acids; Primary structure, Secondary structure, Tertiary structure, Quaternary structure; Homologies in proteins.					
Module:5	Biophysical Analysis: Optical and Spectroscopic techniques	5 hours			
Optical and Spectroscopic techniques for nucleic acid and protein quantification, protein secondary structure determination, biomolecular modifications, etc, by UV-Visible spectroscopy, Fluorescence spectroscopy, IR, NMR and Mass spectroscopy, MALDI, ORD and CD.					
Module:6	Biophysical Analysis: Microscopic Techniques	6 hours			
Macromolecular size determination, Microscopic techniques, Protein aggregation, Self-assembly, Surface morphology, etc, by Light microscopy; Fluorescence microscopy, Atomic force microscope, Electron microscope, Scanning electron microscopy, Transmission electron microscope.					

Module:7	Biophysical Analysis: Chromatographic Techniques & Ultracentrifugation	5 hours		
Protein purification by size exclusion, GPC and ion exchange chromatographic techniques. Ultracentrifugation - Sedimentation velocity and equilibrium-determination of molecular weights.				
Module:8	Contemporary Issues	2 hours		
Industry Expert Lecture				
	Total Lecture hours:			45 hours
Text Book(s)				
1.	Alan Cooper, Biophysical Chemistry, 2 <sup>nd</sup> Edition, RSC Publishing, UK, 2011.			
Reference Books				
1.	Cantor and Schimmel, Biophysical Chemistry, Vols. I - III, W. H. Freeman & Co., USA, 2008.			
2.	J. L. Gurth and A. Gurth, Biophysical Chemistry, 9 <sup>th</sup> Edition, Pragati Prakashan, Meerut, India, 2015.			
3.	P Narayanan, Essentials of Biophysics, 2 <sup>nd</sup> Edition, New Age International, New Delhi, India, 2016.			
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar				
Recommended by Board of Studies			26-02-2024	
Approved by Academic Council			No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY630L	Computational Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<div>1. Providing essential theoretical background of computational chemistry and practical and programming skills to perform scientific computations to solve chemical problems.</div> <div>2. Exposing the students to a variety of computational tools in chemical science.</div>					
Course Outcomes					
<div>1. Assess applicability of computational methods to specific problems in chemistry.</div> <div>2. Apply appropriate computational techniques to study molecules.</div> <div>3. Make use of computational chemistry software and high-performance computer hardware for solving molecular structural problems.</div>					
Module:1	Introduction to Computational Chemistry	4 hours			
The promise of computational chemistry, Potential Energy Surfaces, Computational Strategies- Coordinate systems, Geometry optimization, Local and Global minima, Conformational Analysis, Transition State Optimization, saddle point, vibrational frequencies, and normal mode analysis, Intrinsic Reaction Coordinate (IRC) analysis.					
Module:2	Computational Chemistry Methods-I	6 hours			
Molecular Mechanics-Force field methods, Semi-empirical methods, Variational method, Roothaan-Hall equations, self-consistent field approach, electron spin and Pauli principle, antisymmetric wave functions and Slater determinants.					
Module:3	Computational Chemistry Methods-II	6 hours			
Ab initio methods- Basis sets, Slater and Gaussian functions, polarization and diffuse functions, split-valence sets, correlation-consistent sets, Born-Oppenheimer approximation, Hartree-Fock theory, electron correlation problem, Perturbation theory, Koopmans theorem. Density Functional Theory (DFT) and methods.					
Module:4	Molecular Dynamics Simulations	5 hours			
Basic principles-Equations of motion, force calculations, integration schemes, boundary conditions, phase space and distribution functions, time step and time scale considerations, stability, Practical aspects of simulations, ab initio molecular dynamics. Structural and dielectric properties of a polar medium, SCF reaction field (SCRF), implicit and explicit solvation, solvent Models.					
Module:5	Hybrid Methods and Relativistic Methods	5 hours			
Combined methods, like the combination of quantum chemical methods and molecular mechanics (QM/MM) or ONIOM for the description of biochemical problems, for example the interaction of a drug and a receptor, relativistic quantum chemistry, relativistic effective core potential (RECP).					

<b>Module:6</b>	<b>Introduction to Scientific Computing with FORTRAN</b>			<b>8 hours</b>
Basic elements of Modern FORTRAN programming and its applications in solving computational problems. Writing program for involving simple formulae in organic, inorganic and physical chemistry, developing the algorithm for numerical computation of chemical problems of interest.				
<b>Module:7</b>	<b>Computational Chemistry Concepts</b>			<b>9 hours</b>
Geometrical Parameters, understanding of electrostatic, van der Waals and hydrophobic interactions, Hydrogen bonding, Ground state, Excited States, Transition States - Exploring the energy landscape and its minima, charge density and electron density; Frontier Molecular orbital Analysis, Binding energy, stability constant, Wave function analysis. Structure-Activity Relationships, Descriptors of chemical reactivity and selectivity, DFT reactivity descriptors.				
<b>Module:8</b>	<b>Contemporary Issues</b>			<b>2 hours</b>
Industry Expert Lecture				
<b>Total Lecture hours:</b>				<b>45 hours</b>
<b>Text Book(s)</b>				
1.	F. Jensen, Introduction to Computational Chemistry, 3 <sup>rd</sup> Edition, John Wiley & Sons Ltd, UK, 2017.			
2.	Norman S. Clerman and Walter Spector, Modern Fortran: Style and Usage, Cambridge University Press, New York, USA, 2012.			
<b>Reference Books</b>				
1.	A. Szabo and N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced ElectronicStructure Theory, Dover Publications, New York, 2012.			
2.	Errol G. Lewars, Computational Chemistry: Introduction to the Theory and Applications ofMolecular and Quantum Mechanics, 2 <sup>nd</sup> Edition, Springer, 2011.			
3.	Stephen Wilson, Chemistry by Computer: An Overview of the Applications of Computers inChemistry, Springer, 2011.			
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar				
Recommended by Board of Studies			26-02-2024	
Approved by Academic Council			No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY631L	NMR, EPR and Mass Spectrometry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding the basic principles, theory and instrumentation of <sup>1</sup> H NMR, <sup>13</sup> C NMR, 2DNMR, solid state NMR, EPR and Mass spectrometry.					
2. Imparting knowledge in applications of these spectroscopic techniques					
Course Outcomes					
1. Interpret NMR, EPR and Mass spectra of organic molecules					
2. Apply spectroscopic techniques to understand structure and stereochemistry of organic molecules					
Module:1	Proton NMR	6 hours			
Introduction, Instrumentation: Continuous wave method, Frequency sweep method, pulse technique- Rotating frame of reference-FT NMR-Chemically equivalent and non-equivalent protons- variable temperature spectra-first order spectra, second order spectra-simplification of complex spectra- NOE effects-shift reagents. chemical shift-relaxation processes-spin-spin coupling-coupling constant-the effect of proton exchange reactions- variable temperature spectra-first order spectra, second order spectra-simplification of complex spectra- NOE effects-shift reagents.					
Module:2	<sup>13</sup> C NMR	5 hours			
History-and Problem areas-theory and experiment-sensitivity-Instrumentation - FT-NMR- Pulse technique-Behavior of magnetization subjected to RF pulse.					
Module:3	<sup>13</sup> C NMR applications	9 hours			
Relaxations: spin-lattice and dipole-dipole relaxation and other relaxations - coupling constants- theoretical aspects of nuclear shielding such as local diamagnetic shielding, neighbour anisotropy shielding, local paramagnetic shielding, the factors affecting the Chemical shift-Coupling constants: <sup>1</sup> H & <sup>13</sup> C, <sup>13</sup> C & <sup>13</sup> C and coupling with other nuclei- <sup>1</sup> H decoupling and decoupling methods-empirical relationships and empirical additivity rules- chemical shift reagents, solvent effect-chemical shift and structure elucidations. DEPT methods.					
Module:4	Applications of two dimensional NMR	6 hours			
Introduction and applications of 2D NMR techniques such as H, H-COSY, C, H-COSY, DQF- COSY, MQF-COSY, TOCSY, NOESY, ROESY, HSQC to small molecules.					
Module:5	Solid state NMR	5 hours			
Introduction-Origin-Basic principles and methods of high-resolution NMR of solids-Magic angle spinning- Interactions in the solid state-MAS-CP method and its advantages.					
Module:6	Mass spectrometry	8 hours			
Introduction- Instrumentation-Advanced Ionization techniques such as, ESI, FAB, MALDI, Field desorption-mass analyzers such as Quadrupole Analyzer, ion trap, Time-of -flight Analyzer- Applications of mass spectra to elucidate molecular formula and structure.					

<b>Module:7</b>	<b>ESR Basic Principles and Applications</b>	<b>4 hours</b>
Electronic zeeman effect - ESR spectrum of hydrogen atom (first order treatment) - g factors – Hyperfine constants – interactions affecting the energies of unpaired electrons in the transition metal ion complexes – zero field splitting – Kramer’s degeneracy - anisotropy in the hyperfine coupling constant - nuclear quadrupole interactions - ESR of organic radicals in solution -McConnell’s relation - ESR instrumentation.		
<b>Module:8</b>	<b>Contemporary Issues</b>	<b>2 hours</b>
Industry Expert Lecture		
	<b>Total Lecture hours:</b>	<b>45 hours</b>
<b>Text Book(s)</b>		
1.	Understanding NMR Spectroscopy, James Keeler, Wiley India Pvt Ltd; Second edition, 2013.	
2.	Organic Spectroscopy through Solved Problems, Kali Shankar Mukherjee BodhisattwaMukhopadhyay, First Edition, 2013.	
3.	Organic Spectroscopy Principles, Problems and Their Solutions, Jaggdamba Singh and JayaSingh, A Pragadhi Edition, 2016.	
4.	Elementary Organic Spectroscopy, Principles and Chemical Applications, S.Chand andCompany, Fifth Revised Edition, 2013.	
5.	Introduction to Magnetic Resonance Spectroscopy ESR, NMR, Nqr, D. N. Sathyanarayana, I K International Publishing House Pvt. Ltd; 2nd edition, 2013.	
<b>Reference Books</b>		
1.	Spectroscopy of Organic Compounds by P. S. Kalsi, New Age international Publishers,17 <sup>th</sup> edition, 2016.	
2.	Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X.Webster, David J. Kiemle, David L. Bryce, Wiley, 8 <sup>th</sup> Edition, 2015.	
3.	Principles of NMR Spectroscopy, David Goldenberg, University Science Books; 4 th Edition, 2016.	
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar		
Recommended by Board of Studies		26-02-2024
Approved by Academic Council		No. 73      Date      14-03-2024

Course Code	Course Title	L	T	P	C
PCHY632L	Bioorganic Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding classifications of enzymes and their functions					
2. Creating knowledge on synthesis and structure of nucleic acids, proteins and enzymes					
3. Familiarizing the basic concepts of bioorganic chemistry and biochemical models and their applications in organic synthesis and industry.					
Course Outcomes					
1. Classify enzymes and explain their properties.					
2. Outline the role of biocatalysts in organic synthesis.					
3. Choose biocatalysts for specific organic transformations.					
4. Make use of the concepts of bioorganic chemistry for drug design and to explain drug action.					
Module:1	Biocatalysts in organic synthesis	6 hours			
Enzyme, Properties and Nomenclature, Classification of enzymes, pros and cons of biocatalyst, Mechanistic Aspects, Coenzymes, Enzyme Sources, Immobilized enzymes, comparisons between the homo and heterogeneous biocatalysts					
Module:2	Organic transformations using biocatalysts-I	6 hours			
Organic transformations using biocatalysts: Hydrolysis of esters, amides, phosphates epoxides,nitriles-Oxidations of alcohols, aldehydes, Sulfoxidation, Baeyer-Villiger oxidation, Dihydroxylation of Aromatic Compounds					
Module:3	Organic transformations using biocatalysts-II	6 hours			
Reduction of C=C, aldehydes, ketones- Formation of C-C bond (eg. Aldol, Acyloin, Benzoin, Machael)-Addition and Elimination Reactions by biocatalysts: Cyanohydrin Formation, Addition of Water and Ammonia - Group Transfer Reactions (eg. glycosyl and amino transfer) - Halogenation and De-halogenation reactions,					
Module:4	Enzymes in organic synthesis	5 hours			
Synthesis of esters, Lactones, amides, peptides, peracid, medium engineering					
Module:5	Basics of concepts in bioorganic chemistry	5 hours			
Basic considerations, proximity effects in organic chemistry, molecular adaptation- Bio-isosterism,molecular recognition at the supra molecular level.					
Module:6	Developments in crown ether chemistry - I	8 hours			
Developments in crown ether chemistry- Aza crown ethers-Lariat , Lariat pivot, Bi cyclic, tri cyclic (monoaza, bi-aza, tri-aza), pH regulation and ion-selectivity. Host-Guest complexation chemistry, membrane chemistry-micelles. Bis and Photo responsive crown ethers. Regulation of membrane transport phenomenon.					
Module:7	Developments in crown ether chemistry-II	7 hours			
Cyclodextrines, enzyme design using steroid template, Remote functionalization, biomemetic polyene cyclisation. Chemical mutations and site directed mutagenesis. Chemical mutations and semi synthetic enzymes- Molecular recognition and drug design.					



<b>Module:8</b>	<b>Contemporary Issues</b>			<b>2 hours</b>
Industry Expert Lecture				
	<b>Total Lecture hours:</b>			<b>45 hours</b>
<b>Text Book(s)</b>				
1.	Bio-transformations in Organic Chemistry, Kurt Faber, 7 <sup>th</sup> edition, Springer, 2011.			
2.	An Introduction to Medicinal Chemistry, Graham L Patrick, 5 <sup>th</sup> edition, OUP Oxford, 2013.			
3.	Burger's Medicinal Chemistry & Drug Discovery, Donald J. Abraham, 15 <sup>th</sup> edition, 2014.			
4.	Bioorganic, Bioinorganic and Supramolecular Chemistry, P. S. Kasi and J. P. Kalsi, New Age Publications, 3 <sup>rd</sup> edition, 2017.			
<b>Reference Books</b>				
1.	The Organic Chemistry of Biological Pathways, John E. McMurry and Tadhg P. Begley, 2 <sup>nd</sup> edition, 2015.			
2.	Bio-organic Chemistry, Harish Kumar and Parmjit S. Panesar, Narosa PublishingHouse Pvt. Ltd., New Delhi, 2012.			
3.	Foye's Principles of Medicinal Chemistry, Thomas L. Lemke, David A. Williams, 7 <sup>th</sup> Edition, 2012.			
4.	Biocatalysts: An Industrial Perspective, Gonzalo de Gonzalo; Pablo Domínguez de María, RSC Publishers, 2017.			
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar				
Recommended by Board of Studies			26-02-2024	
Approved by Academic Council			No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY633L	Nanomaterials	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Understanding synthesis, characterization, properties and applications of nanomaterials.					
2. Applying nanomaterials for technological applications.					
Course Outcomes					
1. Propose synthetic techniques for nanomaterials preparation.					
2. Apply characterization techniques to understand the structure and properties of nanomaterials					
3. Explain the chemistry and structure of carbon nanomaterials.					
4. Propose appropriate nanocomposite materials for different applications.					
5. Assess thermal, magnetic, optical, and mechanical properties of nanomaterials.					
6. Fabricate nanodevices for various applications.					
Module:1	Synthesis of nanomaterials	6 hours			
Synthesis: Top-down processes: physical processes- milling, lithographic processes, machining, vapour phase condensation, plasma assisted deposition; Bottom- up processes; micro emulsion technique.					
Module:2	Characterization of nanomaterials	6 hours			
UV - Visible spectroscopy- particle size calculation, particle size analyzer - basic principles - application to selected nanomaterials; Powder XRD - peak broadening, Scherer's equation.					
Module:3	Carbon materials	6 hours			
Graphene, Fullerene, SWNT, MWNT, Functionalised CNT - preparation, properties and applications.					
Module:4	Nanocomposites	6 hours			
Nanocomposites – Metal Matrix nanocomposites, Ceramics matrix nanocomposites, Polymer matrix nanocomposites, metal chalcogenides – Preparation, Properties and applications.					
Module:5	Properties of Nanomaterials	6 hours			
Band diagrams. Electrical transport properties, Thermal transport properties, Magnetic Properties, Optical Properties, Mechanical properties.					
Module:6	Nanodevice fabrication	7 hours			
Nanodevices - introduction- template fabrication, polycarbonate etched track templates, fabrication of anodized alumina membrane - Fabrication of nanostructures in the templates; electrodeposition, sol-gel, CVD methods.					
Module:7	Applications of Nanomaterials	6 hours			
Electronic, magnetic, thermal and biological – application with and an example for each category.					
Module:8	Contemporary Issues	2 hours			
Industry Expert Lecture					

	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	Nanomaterials: An Introduction to Synthesis, Properties and Applications, D. Vollath (Ed), 2 <sup>nd</sup> edition, Wiley VCH, 2013.		
2.	Nanomaterials, Nanotechnologies and Design, Michael F. Ashby, Paulo J. Ferreira and Daniel L. Schodek, Butterworth-Heinemann, 2009.		
3.	Textbook of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, Baldev Raj, B B Rath , James Murday, Universities Press (India) Pvt. Limited, 2013.		
<b>Reference Books</b>			
1.	Essentials in Nanoscience and Nanotechnology, Narendra Kumar, Sunita Kumbhat, John Wiley & Sons, Inc., 2016.		
2.	Materials Chemistry, Bradley D. Fahlman, 3rd edition, Springer Nature B.V. 2018		
3.	NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep (Ed.), McGraw Hill Education, 2017.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

Course Code	Course Title	L	T	P	C
PCHY634L	Green Chemistry	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. Providing ecofriendly methodologies for organic synthesis. 2. Knowing solvent-less and aqueous phase reactions and ultrasound and microwave methodologies. 3. Understanding the application of biocatalysts in organic synthesis 4. Design green processes that reduce or eliminate the use and generation of hazardous substances.					
Course Outcomes					
1. Define green chemistry principles. 2. Make use of green synthetic methods to reduce waste and hazardous materials. 3. Apply phase transfer catalysts, solid phase synthesis and green extraction methods.					
Module:1	Green Chemistry Principles	5 hours			
Evaluating the effects of chemistry. Definition, tools and principles of green chemistry. Wasteminimization, solvent-free and aqueous phase reactions					
Module:2	Green Chemical Approach in Conventional Synthesis	6 hours			
Introduction-Diels alder-Aldol condensation-Heck, oxidation and reduction-photochemical reactions.Alternative solvents- designing a green synthesis. Industrial applications- synthesis of Ibuprofen, Sertraline and Adipic acid.					
Module:3	Green Chemical Approach Under sonication	5 hours			
Sonochemistry - Introduction, types of sonochemical reactions, a few synthetic applications -substitution, addition, elimination, hydrolysis, esterification, oxidation, reduction.					
Module:4	Phase Transfer Catalysts	3 hours			
Definition, mechanisms, reaction, preparation, advantages and types of PTC.					
Module:5	Green Chemical Approach in Conventional Synthesis with PTC	7 hours			
Synthesis of nitriles, alkyl halides, elimination reactions, C-alkylation, N-alkylation, oxidation usinghydrogen peroxide, dihalocarbenes, heterocyclic synthesis, $\beta$ -lactams synthesis, crown ethers.					
Module:6	Green Approach in Solid Phase	11 hours			
Introduction- solid phase organic synthesis without using any solvent- halogenation, Micheal addition, aldol condensation, Grignard reagent, Reformatsky reaction, Witting reaction, aromatic substitution reactions-nuclear bromination and nitration by Green synthetic methods. Biochemical oxidations-biochemical reduction-enzyme catalyzed reactions in organic synthesis					
Module:7	Green Approach in Extraction Process	6 hours			
Extraction and separation of phyto-constituents: hydro extraction, wet steam and dry extraction, head space extraction, super critical fluid extraction, pressurized liquid extraction, Microwave assisted methods, Ultrasonication assisted extraction and					

simulated moving bed technology.			
<b>Module:8</b>		<b>Contemporary Issues</b>	
Industry Expert Lecture		<b>2 hours</b>	
	<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Text Book(s)</b>			
1.	New Trends in Green Chemistry, V. K. Ahluwalia and M. Kidwai, Anamaya Publishers, NewDelhi, 2012.		
2.	Green Chemistry: An Introductory Text, Mike Lancaster, 3 <sup>rd</sup> edition, The Royal Society of Chemistry, 2017.		
3.	Introduction to Green Chemistry, Albert S. Matlack, CRC press, 2010.		
<b>Reference Books</b>			
1.	Alternative Energy Sources, Michaelides, Efstathios E. (Stathis), Springer, Germany, 2012.		
2.	Alternative Solvents for Natural Products Extraction, Farid Chemat, Maryline Abert Vian, Springer Berlin, 2014.		
3.	Green Chemistry in 21st Century and Beyond, Sunita Dhingra & VK Ahluwalia, Manakin Press,2017.		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies		26-02-2024	
Approved by Academic Council		No. 73	Date 14-03-2024

## **Skill Enhancement**

Course Code	Course Title	L	T	P	C
PENG501P	Technical Report Writing	0	0	4	2
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
1. To develop writing skills for preparing technical reports 2. To analyze and evaluate general and complex technical information 3. To enable proficiency in drafting and presenting reports					
Course Outcomes					
At the end of the course, the student will be able to  1. Construct error free sentences using appropriate grammar, vocabulary and style 2. Apply the advanced rules of grammar for proofreading reports 3. Interpret information and concepts in preparing reports 4. Demonstrate the structure and function of technical reports 5. Improve the ability of presenting technical reports					
Indicative Experiments					
1.	<b>Basics of Technical Communication</b> General and Technical communication, Process of communication, Levels of communication				
2.	<b>Vocabulary&amp; Editing</b> Word usage: confusing words, Phrasal verbs Punctuation and Proof reading				
3.	<b>Advanced Grammar</b> Shifts: Voice, Tense, Person, Number Clarity: Pronoun reference, Misplace and unclear modifiers				
4.	<b>Elements of Technical writing</b> Developing paragraphs, Eliminating unnecessary words, Avoiding clichés and slang Sentence clarity and combining				
5.	<b>The Art of condensation</b> Steps to effective precis writing, Paraphrasing and summarizing				
6.	<b>Technical Reports:</b> Meaning, Objectives, Characteristics and Categories				
7.	<b>Formats of reports and Prewriting:</b> purpose, audience, sources of information, organizing the material				
8.	<b>Data Visualization</b> Interpreting Data    Graphs - Tables – Charts - Imagery - Info graphics				
9.	<b>Systematization of Information:</b> Preparing Questionnaire Techniques to Converge Objective-Oriented data in Diverse Technical Reports				
10.	<b>Research and Analyses:</b> Reference styles, Synchronize Technical Details from Magazines, Articles and e-content				
11..	<b>Structure of Reports</b>				

	Title – Preface – Acknowledgement - Abstract/Summary – Introduction - Materials and Methods – Results – Discussion - Conclusion - Suggestions/Recommendations		
12.	<b>Writing the Report:</b> First draft, Revising, Thesis statement, Developing unity and coherence		
13.	<b>Writing scientific abstracts:</b> Parts of the abstract, Revising the abstract Avoiding Plagiarism, Best practices for writers		
14.	<b>Supplementary Texts</b> Appendix – Index – Glossary – References – Bibliography - Notes		
15	<b>Presentation</b> Presenting Technical Reports Planning, creating and digital presentation of reports		
		<b>Total Laboratory hours :</b>	<b>60 hours</b>
<b>Text Book(s)</b>			
1.	Raman, Meenakshi and Sangeeta Sharma, (2015). Technical Communication: Principles and Practice, Third edition, Oxford University Press, New Delhi.		
<b>Reference Books</b>			
1.	Aruna, Koneru, (2020). English Language Skills for Engineers. McGraw Hill Education, Noida.		
2.	Rizvi, M. Ashraf (2018) Effective Technical Communication Second Edition. McGraw Hill Education, Chennai.		
3.	Kumar, Sanjay and Pushpalatha, (2018). English Language and Communication Skills for Engineers, Oxford University Press.		
4.	Elizabeth Tebeaux and Sam Dragga, (2020). The Essentials of Technical Communication, Fifth Edition, Oxford University Press.		
Mode of Evaluation : Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies		19-05-2022	
Approved by Academic Council		No. 70	Date 24-06-2023



Course Code	Course Title	L	T	P	C
PSTS501P	Qualitative Skills Practice	0	0	3	1.5
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives:					
1. To develop the quantitative ability for solving basic level problems. 2. To improve the verbal and professional communication skills.					
Course Outcomes:					
At the end of the course, the student will be able to 1. Execute appropriate analytical skills 2. Solve problems pertaining to quantitative and reasoning ability 3. Learn better vocabulary for workplace communication 4. Demonstrate appropriate behavior in an organized environment					
Module:1	Business Etiquette: Social and Cultural Etiquette; Writing Company Blogs; Internal Communications and Planning: Writing press release and meeting notes				9 hours
Value, Manners- Netiquette, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body– Make it relevant to your audience.					
Module: 2	Time Management Skills				3 hours
Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines					
Module:3	Presentation skills – Preparing presentation; Organizing materials; Maintaining and preparing visual aids; Dealing with questions				7 hours
10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions					
Module:4	QuantitativeAbility-L1–Number properties; Averages; Progressions; Percentages; Ratios				11 hours
Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions					
Module: 5	Reasoning Ability – L1 – Analytical Reasoning				8 hours

Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations, Ordering / ranking / grouping, Puzzle test, Selection Decision table			
<b>Module: 6 Verbal Ability – L1 – Vocabulary Building</b>			<b>7 hours</b>
Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies			
<b>Total Lecture hours:</b>			<b>45 hours</b>
<b>Reference Books</b>			
1	Kerry Patterson, Joseph Grenny, Ron Mcmillan and Al Switzler, (2017), 2 <sup>nd</sup> Edition, Crucial conversatins: Tools for Talking when stakesare High McGraw-Hill contemporary, Bangalore.		
2.	Dale Carnegie,(2016).How to Win Friends and Influence People. Gallery Books, New York.		
3.	Scott Peck. M, (2003). Road Less Travelled. Bantam Press, New York City.		
4.	SMART, (2018). Place Mentor, 1 <sup>st</sup> edition. Oxford University Press, Chennai.		
5.	FACE, (2016). Aptipedia Aptitude Encyclopedia. Wiley publications, Delhi.		
6.	ETHNUS, (2013). Aptimithra. McGraw – Hill Education Pvt .Ltd, Bangalore.		
<b>Websites:</b>			
1.	<a href="http://www.chalkstreet.com">www.chalkstreet.com</a>		
2.	<a href="http://www.skillsyouneed.com">www.skillsyouneed.com</a>		
3.	<a href="http://www.mindtools.com">www.mindtools.com</a>		
4.	<a href="http://www.thebalance.com">www.thebalance.com</a>		
5.	<a href="http://www.eguru.ooo">www.eguru.ooo</a>		
Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies		19-05- 2022	
Approved by Academic Council		No.70	Date 24-06-2023

Course Code	Course Title	L	T	P	C
PSTS502P	Quantitative Skill Practice	0	0	3	1.5
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives:					
1. To develop the students' advanced problem solving skills					
2. To enhance critical thinking and innovative skills					
Course Outcomes:					
At the end of the course, the student will be able to					
1. Create positive impression during official conversations and interviews					
2. Demonstrate comprehending skills of various texts					
3. Improve advanced level thinking ability in general aptitude					
4. Develop emotional stability to tackle difficult circumstances					
Module:1					
Resume skills – Resume Template; Use of power verbs; Types of resume; Customizing resume				2 hours	
Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write-up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout-Understanding different company's requirement, Digitizing career portfolio					
Module: 2				3 hours	
Interview skills – Types of Interview; Use of power verbs; Types of resume; Customizing resume					
Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds					
Module:3				12 hours	
Emotional Intelligence - L1 – Transactional Analysis; Brain storming; Psychometric Analysis; SWOT analysis					
Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure ,Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways, SWOT analysis					
Module:4				14 hours	
Quantitative Ability - L3–Permutation - Combinations; Probability; Geometry and menstruation; Trigonometry; Logarithms; Functions; Quadratic Equations; Set Theory					
Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram					

<b>Module:5</b>	<b>Reasoning ability - L3 – Logical reasoning; Data Analysis and Interpretation</b>	<b>7 hours</b>
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar charts		
<b>Module:6</b>	<b>Verbal Ability - L3 – Comprehension and Critical reasoning</b>	<b>7 hours</b>
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion,( b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
<b>Total Lecture hours:</b>		<b>45 hours</b>
<b>Reference Books</b>		
1.	Michael Farra and JIST Editors,(2011).Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Jist Works, Saint Paul, Minnesota.	
2.	Flage Daniel E, (2003).The Art of Questioning: An Introduction to Critical Thinking. Pearson, London.	
3.	David Allen, (2015).Getting Things done: The Art of Stress-Free productivity. Penguin Books, New York City.	
4.	SMART, (2018). Place Mentor 1 <sup>st</sup> edition. Oxford University Press, Chennai.	
5.	FACE, (2016).Aptipedia Aptitude Encyclopedia. Wileypublications, Delhi.	
6.	ETHNUS, (2013).Aptimithra. McGraw-Hill Education Pvt Ltd, Bangalore.	
<b>Websites:</b>		
1.	<a href="http://www.chalkstreet.com">www.chalkstreet.com</a>	
2.	<a href="http://www.skillsyouneed.com">www.skillsyouneed.com</a>	
3.	<a href="http://www.mindtools.com">www.mindtools.com</a>	
4.	<a href="http://www.thebalance.com">www.thebalance.com</a>	
5.	<a href="http://www.eguru.ooo">www.eguru.ooo</a>	
Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test		
Recommended by Board of Studies		19-05-2022
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