ACADEMIC CURRICULA

POSTGRADUATE DEGREE PROGRAMME

(REGULATIONS 2021)

MASTER OF SCIENCE

(M.Sc. Chemistry)

Two Years(Full-Time)

Learning Outcome Based Curriculum Framework (LOCF)

Academic Year

2021 - 2022

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

TABLE OF CONTENT

SEMESTER III

SEMESTER IV

GENERIC ELECTIVES OFFERED BY CHEMISTRY DEPARTMENT

DEPARTMENT OF CHEMISTRY

1. Department Vision Statement	
Stmt - 1	*To be a nationally and an internationally-acclaimed hub for high-level teaching In chemistry*
Stmt - 2	*To impart research-based education to students in the field of chemistry*
Stmt - 3	*To Implement the global standards and nurturing the students through innovation and quality education.*

2. Department Mission Statement	
Stmt - 1	*To provide comprehensive specialist expertise in the domain of chemistry*
Stmt - 2	*To motivate the next generation graduates to effectively contribute to the advancement of society with integrity and commitment.*
Stmt - 3	*To attain entrepreneurship and self-empowerment in the area of chemical sciences.*

3. Program Education Objectives (PEO)	
PEO - 1	*To develop critical analysis and problem solving skills required in the field of Chemistry*
PEO - 2	*To prepare students with a working knowledge of experimental techniques and instrumentation required to work independently in research or industrial environments.*
PEO - 3	*To develop student strength in organizing and presenting acquired knowledge coherently both orally and in written discourse.*
PEO - 4	*To prepare the students to successfully compete for current employment opportunities*
PEO - 5	*To develop an ability to be socially intelligent with good SIQ (Social Intelligence Quotient) and EQ (Emotional Quotient)*

4. Program Specific Outcomes (PSO)	
PSO - 1	*Students gain in-depth knowledge about the terms, concepts, methodologies, principles and experimental techniques involved in the various fields of chemistry.*
PSO - 2	*Students learn to work in the pure, interdisciplinary and multidisciplinary areas of chemical sciences and its applications*
PSO - 3	*Students acquire the working knowledge of experimental and instrumentation techniques necessary to work independently in research or in other industrial sectors.*

5. Consistency of PEO's with Mission of the Department

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. – 3
PEO - 1	H	H	H
PEO - 2	M	H	M
PEO - 3	M	H	H
PEO - 4	H	H	M
PEO - 5	M	M	M

H – High Correlation, M – Medium Correlation, L – Low Correlation

6. Consistency of PEO's with Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PEO - 1	H	H	H	H	H	L	H	L	H	L	L	H	M	H	H
PEO - 2	H	M	M	H	H	H	H	M	M	M	M	M	H	H	H
PEO - 3	H	H	H	H	H	H	H	M	H	H	H	H	H	L	H
PEO - 4	H	H	M	H	H	H	H	H	H	H	H	H	M	M	H
PEO - 5	M	M	H	H	M	H	M	H	H	H	H	H	H	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

1. PG Programme Structure (Total Credits:80)

1. Professional Core Courses (C)
(10 Courses)

Course Code	Course Title	Hours/ Week			
		L	T*	P	C
PCY21101J	Chemical kinetics, Electrochemistry and Surface Chemistry	2	0	4	4
PCY21102J	Transition Metal Chemistry	2	0	4	4
PCY21103T	Organic chemistry: Structure and Reactivity	3	1	0	4
POC21201T	Spectroscopy and Applications in Organic chemistry	3	1	0	4
POC21202T	Transformations in Organic Chemistry	3	1	0	4
PCY21201T	Classical and Statistical Thermodynamics	3	1	0	4
PCY21202J	Main Group Elements and Nuclear Chemistry	2	0	4	4
PCY21301T	Organometallic and Bioinorganic Chemistry	3	1	0	4
PCY21302T	Quantum Chemistry and Molecular Spectroscopy	3	1	0	4
PCY21303T	Analytical Chemistry	3	1	0	4
Total Learning Credits					**40**

2. Discipline Elective Courses (D)
(3 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PCY21D01T	Chemical Bonding, Molecular Geometry and Group Theory	3	1	0	4
PCY21D02T	Materials Chemistry				
PCY21D03T	Advanced polymer science				
POC21203T	Heterocyclic Chemistry and Total Synthesis of Natural Products	3	1	0	4
POC21D02T	Asymmetric and Enzymatic Synthesis				
PCY21D04T	Nanomaterials and Nanochemistry				
POC21301T	Modern Synthetic Reagents and Photochemistry	3	1	0	4
PCY21D05T	Supramolecular Chemistry and Crystal Engineering				
PCY21D06T	Advanced Electrochemistry				
Total Learning Credits					**12**

3. Generic Elective Courses (G)
(Any 1Course)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PPY21G01T	Energy Storage and Devices	3	0	0	3
PPY21G03T	LASER Physics				
PCY21G01T	Research Skills and Learning				
Total Learning Credits					**3**

4. Skill Enhancement Courses(S)
(3 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PCY21S01J	Fundamentals of Cheminformatics	1	0	2	2
POC21S01L	Organic Chemistry Practical: Functional group analysis and synthesis	0	0	6	3
PCY21S02L	Instrumental Methods of Analysis-Practical	0	0	6	3
Total Learning Credits					**8**

5. Project Work, Internship In Industry / Higher Technical Institutions(P)
(2 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PCY21I01L	Massive Open Online Course	-	-	-	2
PCY21I02L	Internship				
PCY21P01L	Project Work	0	0	24	12
Total Learning Credits					**14**

6.Ability Enhancement Courses (AE)
(3 Courses)

Course Code	Course Title	Hours/ Week			
		L	T	P	C
PCD21AE1T	Professional Skills and Problem Solving	1	0	0	1
PCD21AE2T	General Aptitude for Competitive Examinations	1	0	0	1
PCD21AE3T	Employability Skills	1	0	0	1
Total Learning Credits					**3**

* Additional one hour as open contact hour for each core courses

Course Structure								
Semester	**Professional Core Courses (PCC)**	**Discipline Electives Courses (DEC)**	**Generic Electives Courses (GEC)**	**Skill Enhancement Courses (SEC)**	**Ability Enhancement Courses (AEC)**	**Project Work, Internship (P)**	**Total Credits**	**Total Hours**
I	PCC-1(4) PCC-2 (4) PCC-3(4)	DEC-1 (4)		SEC-1 (2)	AEC-1 (1)		**19**	**24**
II	PCC-4 (4) PCC-5 (4) PCC-6 (4) PCC-7 (4)	DEC-2 (4)		SEC-2 (3)	AEC-2 (1)		**24**	**29**
III	PCC-8(4) PCC-9(4) PCC-10 (4)	DEC-3 (4)	GEC-(3)	SEC-3 (3)	AEC-3 (1)	P (Internship)/ MOOC (2)	**25**	**26**
IV						P (Project) (12)	**12**	**24**
Total Credits	**40**	**12**	**3**	**8**	**3**	**14**	**80**	**103**

2. Implementation Plan

Semester - I

Course Code	Course Title	Hours/ Week L	T	P	C
PCY21101J	Chemical kinetics, Electrochemistry and Surface Chemistry	2	0	4	4
PCY21102J	Transition Metal Chemistry	2	0	4	4
PCY21103T	Organic chemistry: Structure and Reactivity	3	1	0	4
PCY21D01T	Chemical Bonding, Molecular Geometry and Group Theory	3	1	0	4
PCY21D02T	Materials Chemistry				
PCY21D03T	Advanced Polymer Science				
PCY21S01J	Fundamentals of Cheminformatics	1	0	2	2
PCD21AE1T	Professional Skills and Problem Solving	1	0	0	1
	Total Learning Credits				19
	Total Number of Hours				24

Semester - II

Course Code	Course Title	Hours/ Week L	T	P	C
POC21201T	Spectroscopy and Applications in Organic chemistry	3	1	0	4
POC21202T	Transformations in Organic Chemistry	3	1	0	4
PCY21201T	Classical and Statistical Thermodynamics	3	1	0	4
PCY21202J	Main Group Elements and Nuclear Chemistry	2	0	4	4
POC21203T	Heterocyclic Chemistry and Total Synthesis of Natural Products	3	1	0	4
POC21D02T	Asymmetric and Enzymatic Synthesis				
PCY21D04T	Nanomaterials and Nanochemistry				
POC21S01L	Organic Chemistry Practical: Functional group analysis and synthesis	0	0	6	3
PCD21AE2T	General Aptitude for Competitive Examinations	1	0	0	1
	Total Learning Credits				24
	Total Number of Hours				29

Semester – III

Course Code	Course Title	Hours/ Week L	T	P	C
PCY21301T	Organometallic and Bioinorganic Chemistry	3	1	0	4
PCY21302T	Quantum Chemistry and Molecular Spectroscopy	3	1	0	4
PCY21303T	Analytical Chemistry	3	1	0	4
POC21301T	Modern Synthetic Reagents and Photochemistry	3	1	0	4
PCY21D05T	Supramolecular Chemistry and Crystal Engineering				
PCY21D06T	Advanced Electrochemistry				
PCY21S02L	Instrumental Methods of Analysis- Practical	0	0	6	3
PPY21G01T	Energy Storage and Devices	3	0	0	3
PPY21G03T	LASER Physics				
PCY21G01T	Research skills and learning				
PCY21I01L	Massive Open Online Course	-	-	-	2
PCY21I02L	Internship				
PCD21AE3T	Employability Skills	1	0	0	1
	Total Learning Credits				25
	Total Number of Hours				26

Semester - IV

Course Code	Course Title	Hours/ Week L	T	P	C
PCY21P01L	Project Work	0	0	24	12
	Total Learning Credits				12
	Total Number of Hours				24

Total Learning Credits :80

3. Program Articulation Matrix

Course Code	Course Name	Programme Learning Outcomes														
		Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	Ethical Reasoning	Community Engagement	ICT Skills	Leadership Skills	Life Long Learning
PCY21101J	Chemical kinetics, Electrochemistry and Surface Chemistry	H	H	H	H	H	M	M	M	M	M	H	H	M	H	H
PCY21102J	Transition Metal Chemistry	H	H	H	H	H	L	M	L	M	H	M	M	H	H	H
PCY21103T	Organic Chemistry: Structure and Reactivity	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
POC21201T	Spectroscopy and Applications in Organic chemistry	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
POC21202T	Transformations in Organic Chemistry	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
PCY21201T	Classical and Statistical Thermodynamics	H	H	H	H	H	H	H	H	H	H	H	L	M	L	H
PCY21202J	Main Group Elements and Nuclear Chemistry	H	H	H	H	M	M	M	H	H	H	M	M	H	M	H
PCY21301T	Organometallic and Bioinorganic Chemistry	H	H	H	H	H	L	M	L	M	M	H	H	M	H	H
PCY21302T	Quantum Chemistry and Molecular Spectroscopy	H	H	M	H	H	L	M	L	M	H	M	M	H	H	H
PCY21303T	Analytical Chemistry	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
PCY21D01T	Chemical Bonding, Molecular Geometry and Group Theory	H	M	M	H	H	H	M	H	H	H	H	L	M	M	H
PCY21D02T	Materials Chemistry	H	M	M	H	H	H	M	H	H	H	H	L	M	M	H
PCY21D03T	Advanced Polymer Science	H	H	H	H	H	L	M	L	M	M	H	H	M	H	H
POC21203T	Heterocyclic Chemistry and Total Synthesis of Natural Products	H	H	H	H	H	L	M	L	M	H	M	M	H	H	H
POC21D02T	Asymmetric and Enzymatic Synthesis	H	H	H	H	H	M	H	M	M	M	H	H	H	M	H
PCY21D04T	Nanomaterials and Nanochemistry	H	M	M	H	H	H	M	H	H	H	H	L	M	M	H
POC21301T	Modern Synthetic Reagents and Photochemistry	H	M	H	H	M	H	M	H	H	H	M	M	H	M	H
PCY21D05T	Supramolecular Chemistry and Crystal Engineering	H	H	H	H	H	L	M	L	M	M	H	H	M	H	H
PCY21D06T	Advanced Electrochemistry	H	H	H	H	H	L	M	L	M	H	M	M	H	H	M
PPY21G01T	Energy Storage and Devices	H	H	H	H	H	M	H	M	M	M	H	H	H	M	M
PPY21G03T	LASER Physics	M	M	H	H	M	H	M	H	H	H	M	M	H	M	M
PCY21G01T	Research Skills and Learning	H	H	H	H	M	H	M	H	H	H	M	M	H	M	M
PCY21S01J	Fundamentals of Cheminformatics	H	H	H	H	H	L	M	L	M	M	H	H	M	H	H
POC21S01L	Organic Chemistry Practical: Functional group analysis and synthesis	H	H	H	H	H	L	M	L	M	H	M	M	H	H	M
PCY21S02L	Instrumental Methods of Analysis- Practical	H	H	H	H	H	M	H	M	M	M	H	H	H	M	M
PCY21I01L	Massive Open Online Course	M	M	H	H	M	H	M	H	H	H	M	M	H	M	M
PCY21I02L	Internship	M	M	H	H	M	H	M	H	H	H	M	M	H	M	M
PCY21P01L	Project Work	H	H	H	H	H	L	M	L	M	M	M	H	M	H	H
PCD21AE1T	Professional Skills and Problem Solving	H	H	H	H	H	M	H	M	M	M	H	H	H	M	M
PCD21AE2T	General Aptitude for Competitive Examinations	H	M	M	H	H	H	M	H	H	H	H	L	M	M	H
PCD21AE3T	Employability Skills	M	M	H	H	M	H	M	H	H	H	M	M	H	M	M
PCY21G02T	Chemistry of Biomolecules	H	H	H	H	M	H	M	H	H	H	M	M	H	M	M
	Program Average	H	H	H	H	H	L	M	L	M	H	M	M	H	H	H

H – High Correlation, M – Medium Correlation, L – Low Correlation

SEMESTER I

Course Code	PCY21101J	Course Name	Chemical kinetics, Electrochemistry and Surface Chemistry	Course Category	C	Professional Core Course	L	T	P	C
							2	0	4	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Help the student to understand the basic principles of chemical kinetics.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	Gain the knowledge of chemical reaction in solutions and effect of dielectric constants.																		
CLR-3 :	*Gain deeper insight of complex and fast reactions.*																		
CLR-4 :	*Gather basic knowledge of general acid base catalyzed reaction and enzyme catalyzed reaction.*																		
CLR-5 :	Gain knowledge of the basic electrochemistry.																		
CLR-6 :	*Understand the mechanism of surface adsorption process in terms of thermodynamics and chemical kinetics.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	Understand the basic principles of chemical kinetics.	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	*Gain knowledge about the fast reaction kinetics*	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Understand the mechanisms of chemical reactions in gas phase and in liquid.	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Acquaint the student with the fundamental concepts of basic electrochemistry	2	70	70	H	V	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Understand the basic principles of chemisorption, BET and BET related isotherms.	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Understand the principles of determination of molecular weight, phase diagram of two components forming a simple eutectic, rate of polymerization of acrylamide	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		18	18	18	18	18
S-1	SLO-1	Simple collision theory	Solvent effects on reaction rates, cage effect	Electromotive force - measurement of EMF	Equilibrium isotope effects	Adsorption of gases and vapors on solids
	SLO-2	Absolute reaction rate theory (ARRT)	factors determining the reaction rates in solution(based on transition state theory)	the cell EMF and the cell reaction	Primary kinetic isotope effects,	Langmuir adsorption isotherm
S-2	SLO-1	Thermodynamic treatment,potential energy surfaces	reactions between ions	reversible cells - types of half cells - classification of cells	Secondary kinetic isotope effects	kinetic and statistical derivation of Langmuir adsorption isotherm
	SLO-2	Application of ARRT to simple bimolecular process	ion-dipole and dipole dipolereactions,	the standard EMF of a cell -electrochemical potential - standard electrode potentials	Fast reactions: relaxation kinetics	kinetic and statistical derivation of Langmuir adsorption isotherm

Duration (hour)		18	18	18	18	18
S-3-6	SLO-1	Introduction and demonstration of the lab instruments	Determination of Ea of saponification of Ester by conductometry method	Determination of strength of an acid by conductometry	Determination of effect of impurity on the CST of phenol- water system	Study of phase diagram of three components system.
	SLO-2					
S-7	SLO-1	chain reactions, general characteristics	structure, significance of volume and entropy of activation, pressure effect	calculation of the EMF of a cell	Fast reactions: relaxation kinetics, chemical relaxation in two step and multi-step synthesis	adsorption entropies
	SLO-2	study of kinetics of chain reaction like H_2-Br_2 reaction	Primary and secondary salt effects.	Nernst equation and its limitations	experimental methods for the study of relaxation kinetics and applications	lateral interactions
S-8	SLO-1	decomposition of acetaldehyde and N_2O_5	Kinetics of photophysical and photochemical processes	electrode concentration cells	experimental methods for the study of relaxation kinetics and applications	the BET and related isotherms
	SLO-2	Theory of unimolecular reactions,	complex photochemical processes, homogeneous catalysis	cells with liquid junctions	temperature jump method	the BET and related isotherms
S-9-12	SLO-1	Determination of rate constant of Acid hydrolysis of an ester	Determination of molecular weight of substance by Transition Temperature method	Determination of strength of an Iron solution by Potentiometric method	Study of phase diagram of two components forming a simple eutectic	Determination of rate of polymerization of acrylamide
	SLO-2					
S-13	SLO-1	Lindemann, Hinshelwood	general catalytic mechanisms,	decomposition voltages	diffusion controlled reactions	derivation of the BET equation
	SLO-2	steady state approximation	acid-base catalysis,	concentration polarisation and over voltage	diffusion controlled reactions	properties of the BET equation
S-14	SLO-1	Principle of microscopic reversibility	catalysis by enzymes,	Kinetics of electrode process. Electrical aspects of surface chemistry,	fluorescence quenching, Electrochemical methods	thermodynamics of adsorption chemisorption and catalysis
	SLO-2	And detailed balancing	influence of concentration (single substrate, double substrate)	electrical double layer, Stern treatment of the electrical double layer, free energy of a diffuse double layer	common ion inhibition, flash photolysis	kinetics of chemisorption
S-15-18	SLO-1	Determination of order, effect of ionic strength on rate constant of Persulphate-Iodine reaction.	Determination of equivalent conductance, degree of dissociation and dissociation constant of weak acid by conductometry.	Determination of Critical Solution Temperature (CST) of phenol- water system	Study of phase diagram of two components forming a compound	Determination of integral and differential heat of solutions by colorimetry.
	SLO-2					

Learning Resources	1. K.J. Laidler, Chemical Kinetics, Tata McGraw Hill 2. Gurdeep Raj, Chemical Kinetics, Goel Publishing House. 3. P.W.Atkins, Physical Chemistry 4. P.C. Hiemenz, *Principles of colloids and surface chemistry*,2ndEd.,Marcel DekkerInc., 1986.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
	Understand										
Level 2	Apply	40%	40%	50%	50%	50%	50%	50%	50%	50%	50%
	Analyze										
Level 3	Evaluate	30%	30%	20%	20%	20%	20%	20%	20%	20%	20%
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. Manab Kundu, SRMIST
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Course Code	PCY21102J	Course Name	Transition Metal Chemistry	Course Category	C	Professional Core Course	L	T	P	C
							2	0	4	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Motivate the learners to understand the different types coordination complexes.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	Distinguish and intervene the theories of coordination complexes of d-block elements with variable configurations.																		
CLR-3 :	Identify as well as to predict the feasibility and stability of coordination complexes																		
CLR-4 :	Compare the physicochemical properties of the complexes against spectroscopic and magnetic properties.																		
CLR-5 :	Study the synthetic strategies based on the reactivity with respect to structural and fundamental factors.																		
CLR-6 :	Acquire the trend and features of compounds of lanthanides and actinides.																		
CLO-1 :	Deduce the structure of different types of coordination complexes.	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Correlate the gradational development of theories of coordination complexes due to splitting of orbitals.	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Predict the spectroscopic and magnetic properties of the metal-ligand coordination spheres.	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Conclude the type of reactions to be occurred with the variety of the metal complexes	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Understand the versatile mechanistic pathways associated with the reactions of different coordination sphere	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Appreciate the significance of f-block elements chemistry based on their characteristic properties.	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:

Duration (hour)		18	18	18	18	18
S-1	SLO-1	Introduction monodentate, bidentate, and polydentate ligands	Valence bond theory: hybridization,	Magnetic properties of tetrahedral and octahedral complexes	Ligand substitution reactions in octahedral, square planar complexes,	Lanthanides: lanthanide series, abundance and natural isotopes
	SLO-2	coordination sphere coordination number	geometry, magnetism, drawbacks of VBT	para, dia, ferromagnetism and antiferro magnetism, determination of magnetic properties, Gouy's method	labile and inert complexes (application of VBT, MOT), dissociation, association mechanism,	lanthanide contraction, similarity in properties, occurrence, oxidation states,
S-2	SLO-1	nomenclature of mononuclear and dinuclear complexes	Crystal field theory: crystal field effects, assumptions of crystal field theory,	anomalous magnetic moment, thermal effects	mechanism of hydrolysis reactions, acid hydrolysis, base	chemical properties of Ln(III) cations

Duration (hour)		18	18	18	18	18
					hydrolysis, anation reactions,	
	SLO-2	chelate effect, Werner's theory and Sidgwick theory	crystal field splitting in octahedral and tetrahedral geometries, qualitative crystal field splitting diagrams, high-spin and low-spin complexes	single molecular magnets, spin and orbital contribution quenching,	trans effect, trans influence, trans effect and its application,	magnetic properties, colour and electronic spectra of lanthanide compounds,
S-3-6	SLO-1	Introduction to Inorganic Chemistry Lab	Synthesis of Metal acetylacetonate complex	*Cis* and *trans* isomers of $[Co(en)_2Cl_2]Cl$	Preparation of Ferrocene.	Preparation of triphenyl phosphene (Ph_3P), and transition metal complexes
	SLO-2					
S-7	SLO-1	EAN and formation of metal-metal bond in dimers	CFSP and factors affecting it, computation of CFSE	Spin cross over rule, microstates of electron configuration in free atoms and ions	theories of trans effect, thermodynamic and kinetic stability of complexes, factors affecting stability of metal complexes	separation of lanthanides, solvent extraction, ion exchange method
	SLO-2	stability of complexes, determination of stability constants	evidences of crystal field splitting, spectrochemical series	term symbols for equivalent and nonequivalent electrons, possible term symbols for given configuration,	experimental determination of stability constant of complexes	separation of lanthanides, solvent extraction, ion exchange method
S-8	SLO-1	Jobs method, stepwise stability constant	Jahn-Teller theorem, crystal field splitting in tetragonally distorted octahedral geometry and in square planar geometry	p2 -d2 splitting of terms in square planar, tetrahedral, octahedral fields, electronic spectra of various complexes,	Electron transfer reactions, one electron transfer reactions, inner sphere mechanism, outer sphere mechanism	Actinides: actinide series, abundance and natural isotopes, occurrence
	SLO-2	overall stability constant, factors affecting stability of coordination compounds	Jahn-Teller theorem, crystal field splitting in tetragonally distorted octahedral geometry and in square planar geometry	selection rules, spin orbit coupling, assignment and intensities of transitions	Electron transfer reactions, one electron transfer reactions, inner sphere mechanism, outer sphere mechanism	preparation of actinides, oxidation states, general properties, the later actinide elements,
S-9-12	SLO-1	Determination of Cr(III) complexes. $[Cr(H_2O)_6]NO_3.3H_2O$; $[Cr(H2O)_4Cl_2]Cl.2H_2O$; $[Cr(en)_3]Cl_3$; $Cr(acac)_3$	Preparation of Tin(IV) iodide, Tin(IV) chloride, and Tin(II) iodide.	(*N,N*)-bis(salicyldehyde)ethylenediamine Salen H_2; and its cobalt complex [Co(Salen)]	Reaction of Cr(III) with multidentate ligands, a kinetics experiment - Vanadyl acetylacetonate.	Reaction of Mixed valence dinuclear complex of Mangenese(III,IV).
	SLO-2					
S-13	SLO-1	charge of central metal ion, size of central metal ion	covalency in transition metal complexes,	Orgel (d1 to d9 octahedral and tetrahedral complexes) and Tanabe Sugano diagrams(d1,d6 complexes and its applications),	Marcus theory and its applications, two electron transfer reactions complementary and non - complementary electron transfer reactions	uranium-occurrence, metallurgy; chemical properties of hydrides,
	SLO-2	chelate ring size, steric effects	evidences for covalency, intensity of d-d transitions, spin-spin splitting, hyperfine splitting, adjusted crystal field theory.	Orgel (d1 to d9 octahedral and tetrahedral complexes) and Tanabe Sugano diagrams(d1,d6 complexes and its applications),	synthesis of coordination compounds using electron transfer reactions, metal assisted reactions	uranium-occurrence, metallurgy; chemical properties of hydrides,

Duration (hour)		18	18	18	18	18
S-14	SLO-1	Isomerism: linkage, ionization, hydrate, coordination, coordination position isomerism,	MO Theory: metal orbitals and LGOs suitable for σ and π bonding in octahedral geometry,	calculation of D0 and b and Racah parameters, examples from d2, d3 d7, d8 octahedral complexes	aldol condensation, ester hydrolysis,phosphate ester, aminoesters and amide hydrolysis, template effect,	oxides, and halides
	SLO-2	geometrical (*cis* and *trans*, and *fac* and *mer*) and optical isomerism.	construction of qualitative MO energy level diagram for bonding in octahedral geometry.	charge transition spectra of metal complexes	synthesis of macrocyclic ligands, reaction of coordinated ligands.	complexes of lanthanides and actinides.
S-15-18	SLO-1	Synthesis of inorganic complexes characterization by physicochemical methods, viz. FT-IR, UV, Vis, NMR and magnetic susceptibility etc.	Any one new novel synthesis reported in recent literature	Analysis of metal complexes to deduce its structure.	pH meter based measurements	Potentiometer based measurements
	SLO-2					

Learning Resources	
	1. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rdEd., W. H. Freeman and Co, London, 1999. *2. J. E. Huheey, E. A. Kieter and R. L. Keiter, Inorganic Chemistry, 4thEd., Harper Collins, New York, 1993* *3. F. A. Cotton, G. Wilkinson and P.L.Gaus, Basic Inorganic Chemistry, 3rd Ed., John Wiley, New York, 2008.* *4. N.N. Greenwood and A.Earnshaw, Chemistry of the Elements, 2nd Ed., Pergamon Press, Oxford, 2005 (Reprint).* *5. B.Douglas, D.McDaniel and J.Alexander, Concepts and Models of Inorganic Chemistry, 3rd Ed., Wiley, 2013.* *6. Inorg. Synth. 1957, **5**, 130; 1963, **1**, 183.* *7. J. Chem. Soc., 1960, 4369.* *8. J. Chem., Educ., 1980, **57**, 316; 1978, **55**, 55.* *9. J. Chem. Educ. 1966, **43**, 73; 1976, **53**, 730.* *10. Inorg. Synth. 1953, **4** 119.* *11. J. Chem. Educ. 1977, **54**, 443, 1973, **50**, 670.*

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	30%	30%	30%	30%	30%	30%	30%	50%	50%
	Understand										
Level 2	Apply	40%	40%	50%	50%	50%	50%	50%	50%	50%	50%
	Analyze										
Level 3	Evaluate	30%	30%	20%	20%	20%	20%	20%	20%	40%	60%
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. M. Arthanareeswari, SRMIST

Course Code	PCY21103T	Course Name	Organic Chemistry: Structure and Reactivity	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Gain exposure to the field of aromatic compounds																		
CLR-2 :	Gain knowledge about the mechanism of a reaction																		
CLR-3 :	Learn about the reaction intermediates																		
CLR-4 :	Gain insight about how a molecule arrange in 3D space																		
CLR-5 :	Know different types of reactions like substitution and elimination																		
CLR-6 :	Learn about the reactivity of carbonyl compounds																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	Understand the concept of aromaticity	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Recognize reaction mechanism	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Realize reaction pathways	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Visualize molecules in 3D space and understand the arrangements of different atoms around a carbon center	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Know how carbonyl compounds cab ne utilized in organic transformation	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Design reaction scheme for the synthesis of a chiral compound	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Aromaticity, anti-aromaticity and Non aromatic compounds	conformational analysis: acyclic system	SN1, SN2, SNi and NGP,	E2, E1, E1cb and E2C mechanisms	Introduction to carbonyl compounds
	SLO-2	Hückel's rule of aromaticity	conformational analysis: acyclic system	nucleophilic substitutions at allylic, aliphatic and vinyl carbons	stereochemistry	Nucleophilic addition to carbonyl compounds
S-2	SLO-1	homo-aromaticity	cyclic systems	effect of substrate, nucleophile, leaving group, and medium,	Hoffmann and Saytzeff rules	stereochemistry of nucleophilic additions
	SLO-2	neutral and charged aromatic systems (3, 4, 5, and 7- membered ring systems)	cyclic systems	stereochemistry, ambident nucleophiles	effect of substrate, base, leaving group and medium, pyrolytic eliminations	Cram's rule, Felkin-Anh model
S-3	SLO-1	annulenes and fused rings systems	effect of conformation on reactivity	Aromatic electrophilic substitution, mechanism and reactivity	Chugaev reaction, Cope elimination	chemistry of imines
	SLO-2	Hetero annulenes, aromaticity of	effect of conformation on	selectivity and orientation, the effect	Bamford-Stevens reaction, Sandmeyer	enolates, keto-enol tautomerism

Duration (hour)		12	12	12	12	12
		heterocycles	reactivity	of leaving group	reaction	
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-5	SLO-1	Types of mechanisms, transition states and intermediates	elements of symmetry	nitration, nitrosation and diazonium coupling	Addition reactions to double bonds	condensation reactions of carbonyl compounds
	SLO-2	thermodynamic and kinetic requirements,	chirality	sulphonation, chlorination, bromination	triple bonds	aldol condensations (acid and base catalyzed aldol condensation, crossed aldol condensation
S-6	SLO-1	Hammond postulate, Curtin-Hammett principle, methods of determining mechanisms	molecules with more than one chiral center	Friedel-Crafts alkylation,	electrophilic, nucleophilic additions	Claisen-Schmidt condensation, directed aldol condensations
	SLO-2	isotopic effects,	projection formulae (i) Fischer (ii) Sawhorse	Friedel-Crafts acylation and arylation	free radical additions, orientation and reactivity	Mukaiyama aldol condensation, Claisen ester condensation
S-7	SLO-1	Hammett equation and linear free energy relationship (sigma-rho) relationship	(iii) Newman (iv) Flying Wedge	aromatic nucleophilic substitutions: SNAr, SN1	stereochemistry of addition reactions	Dieckmann reaction, Stobbe condensations,Acyloin condensation
	SLO-2	Taft equation and its application	threo and erythro isomers	benzyne mechanisms	Ring opening of cyclopropanes	Knoevenagel condensations, 1,4-conjugate additions (Michael addition), Robinson annulation
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-9	SLO-1	Reaction intermediates: Generation, structure, stability, and reactivity	methods of resolution	Sommelet-Hauser, Von Richter and Smiles rearrangement,	Addition of hydrogen halides (Markownikov's rule) and bromine	Wittig reactions, Mannich reactions
	SLO-2	carbocations	specific rotation, optical purity and enantiomeric excess	Bucherer and Rosenmund reactions	halohydrin formation, hydroboration (anti-Markownikov's rule)	nucleophilic addition to isocyanates and isothiocyanates
S-10	SLO-1	carbanions	enantiotopic and diastereotopic atoms, groups and faces	aliphatic substitution mechanisms, SE2, SEi and SE1	hydrozirconation, iodolactonization	esterification reactions
	SLO-2	free radicals	enantiotopic and diastereotopic atoms, groups and faces	addition-elimination and cyclic mechanisms, halogenations of ketones, aldehydes and carboxylic acids	bromolactonization, oxymercuration	ester hydrolysis
S-11	SLO-1	carbenes, nitrenes	stereospecific and stereoselective reactions	aliphatic diazonium coupling, sulphonation, sulphenylation,	hydrogenation reactions (hydrogenation of C=C double bonds, triple bonds, and aromatic rings)	Mcmurry coupling, Tabbe reagent

Duration (hour)		12	12	12	12	12
	SLO-2	benzyne, non-classical carbocations	optical activity in the absence of chiral carbon	Stork enamine alkylation and acylation, carbene and nitrene insertions, Kolbe-Schmidt reaction.	Koch reaction	Pinacol Coupling Reaction, haloform reaction.
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					

Learning Resources	**1.** M. B. Smith and J. March, March's Advance Organic Chemistry, 6th Ed., John Wiley and Sons, Inc. **2.** J. Clayden, N. Greeves, and S. Warren, Organic Chemistry 2nd Ed., Oxford. **3.** J. McMurry, Organic Chemistry 5th Ed., Thomson. **4.** T. W. G. Solomons and C. B. Fryhle, Organic Chemistry 10th Ed.,John Wiley and Sons, Inc. **5.** I. L. Finar and A. L. Finar, Organic Chemistry Vol. 2, Addison-Wesley. **6.** D. N. Nasipuri, Stereochemistry of Organic Compounds: Principles & Applications South Asia Books.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. Anjan Bedi, SRMIST

Course Code	PCY21D01T	Course Name	Chemical Bonding, Molecular Geometry and Group Theory	Course Category	D	Discipline Elective Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Recite the types of bonds and illustrate the structure of crystals																		
CLR-2 :	Solve the radius ratio of the crystals, enthalpy of formation of ionic compounds and Identify the various crystal defects																		
CLR-3 :	Summarize the molecular geometry, structure of covalent compounds																		
CLR-4 :	Analyze and differentiate the various weak chemical forces and bonding in metals																		
CLR-5 :	Discuss the acidity and basicity of acids and bases based on various concepts																		
CLR-6 :	Explore the mathematical calculation based on group theory and find its application in chemistry																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	Define the types of bonds and draws the structures of crystals	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Calculate the radius ratio of the crystal and enthalpy of formation of ionic compounds	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Explain the molecular topologies of covalent compounds and illustrate the MOT	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Relate the weak chemical bonding forces in predicting the properties of compounds and metals	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Distinguish the acidity and basicity of acids and bases	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Identify the molecular vibrations and chirality in compounds using group theory	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Chemical bond, types of bonds, ionic bond	covalent character in ionic compounds, polarization and	orbital mixing, heteronuclear diatomic molecules	proton transfer equilibria under aqueous conditions	Symmetry elements
	SLO-2	properties of ionic compounds	Fajan's rules, effects of polarization, solubility, melting points and thermal stability of typical ionic compounds	polar bonds, ionic compounds, and molecular orbitals, molecular orbitals of polyatomic molecules	proton transfer equilibria under aqueous conditions	Symmetry elements
S-2	SLO-1	factors favoring the formation of ionic compounds	Crystal defects, Schottky defects	Vander Waals forces	non-aqueous solvents and acid-base strength	Symmetry operations
	SLO-2	ionization potential, electron affinity and electronegativity	controlled valency, F-center	inclusion compounds	non-aqueous solvents and acid-base strength	Symmetry operations
S-3	SLO-1	packing of ions in crystals and	Frenkel defect, non-stoichiometric	Layer, channel structures	periodic trends in aqua acid strength,	point groups

Duration (hour)		12	12	12	12	12
	SLO-2	crystal structures, ccp, hcp, bcc, fcc	interstitial and electron deficient compounds.	cage structures (gas hydrates and clathrates)	oxoacids, anhydrous oxides,	point groups
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	radius ratio and	Molecular topologies: shared and lone pairs and	Hydrogen bonding: types	Bronsted-Lowry acidity of aqueous cations,	groups and classes of symmetry operations
	SLO-2	structure of ionic lattices	Lewis structures	Hydrogen bonding: types	Bronsted-Lowry acidity of aqueous cations,	groups and classes of symmetry operations
S-6	SLO-1	geometrical method of computing radius ratios	isoelectronic and	non-conventional hydrogen bonding,	Lewis acid- base concept and frontier orbitals,	non-degenerate representations,
	SLO-2	relation between radius ratio and coordination number	isolobal relationships,	associated molecules, molecular self-assembly	examples of Lewis acids and bases,	non-degenerate representations,
S-7	SLO-1	Stoichiometry and	hybridization and geometry	supramolecular architectures formed by weak chemical forces.	quantification of Lewis basicity,	Great Orthogonality theorem
	SLO-2	crystal structures	hybridization and geometry	supramolecular architectures formed by weak chemical forces.	inductive and steric effects on Lewis acidity and basicity,	Great Orthogonality theorem
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	SLO-1	Lattice energy: definition, Born-Lande equation	VSEPR model	Bonding in metals: packing of atoms in metals,	frustrated Lewis pairs	Construction of character table
	SLO-2	factors affecting lattice energy	VSEPR model	Bonding in metals: packing of atoms in metals,	frustrated Lewis pairs	Construction of character table
S-10	SLO-1	Born-Haber cycle	molecular orbital theory, linear combination of atomic orbitals	band theory of metals and metallic properties	hard and soft acids and bases,	reduction formula, character of matrices
	SLO-2	enthalpy of formation of ionic compounds and stability	bonding, antibonding andnon-bonding molecular orbitals	insulators and semiconductors	hard and soft acids and bases,	degenerate representations
S-11	SLO-1	calculation of ionic radius, Pauling's method and	MOs of homonuclear diatomic molecules	Bronsted-Lowry concept	thermodynamic acidity parameters, superacid and superbase.	applications to molecular vibrations (IR and Raman activity) and chirality.
	SLO-2	Linde's method, effective nuclear charge, Slater's rule,	MOs of homonuclear diatomic molecules	Bronsted-Lowry concept	thermodynamic acidity parameters, superacid and superbase.	applications to molecular vibrations (IR and Raman activity) and chirality.
S-12	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

Learning Resources	
	1. D. F.Shriver, P. W.Atkins and C. H. Langford, *Inorganic Chemistry*, 3rdEd., Oxford University Press, London, 2001
	2. J. E.Huheey, E. A.Keiter and R. L. Keiter, *Inorganic Chemistry*, 4thEd., Harper and Row, NewYork, 1983
	3. A.Vincent,*Molecular Symmetry and Group Theory. A Programmed Introduction to Chemical Applications*, JohnWiley& Sons Ltd, 1977.
	4. F. Albert Cotton, *Chemical Applications of Group Theory*, 2ndEd., John Wiley & Sons, 1971.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	PCY21D02T	Course Name	Materials Chemistry	Course Category	D	Discipline Elective Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Introduce the science of materials chemistry																		
CLR-2 :	Deepen the knowledge on crystalline materials with a focus on their synthesis methods																		
CLR-3 :	Improve the understanding of amorphous, electronic materials and their applications																		
CLR-4 :	Understand the fundamentals of nanomaterials and their applications																		
CLR-5 :	Gain knowledge about mechanical, magnetic and electrical properties of materials along with their technological relevance																		
CLR-6 :	Enlighten with basic principles of various analytical techniques for characterization of materials																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	Understand different types of materials, their properties, characterization and applications	2	75	60	H	H	H	L	H	H	M	H	H	-	H	H	H	H	H
CLO-2 :	Well aware of various chemical, physical methods of crystalline materials synthesis	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Gain knowledge about amorphous materials, polymer materials and band theory of solids	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Acquaint with the fundamental concepts of nanomaterials and their importance	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Familiar with the mechanical, magnetic and electrical properties of the materials and their technological relevance	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Identify the suitable analytical techniques and perform the characterization of materials	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Crystalline materials: introduction	Amorphous solids: Introduction	Nanomaterials: Introduction	Mechanical properties: introduction	Spectroscopic methods: Introduction
	SLO-2	Crystalline materials: introduction	A comparison of crystalline and amorphous materials in terms of properties and applications	Examples of a variety of nanomaterials	Various mechanical properties and their importance	Spectroscopic methods: Introduction
S-2	SLO-1	Fundamentals of lattice	oxide glasses	Quantum confinement	ductile fracture	UV-Vis: Instrumentation, basic working principles
	SLO-2	Unit cell	chalcogenide glasses	quantum nanostructures	brittle fracture	Examples in Analysis
S-3	SLO-1	Atomic coordinates	amorphous carbon	surface energy of nanomaterials	toughness	IR: Instrumentation, basic working principles

Duration (hour)		12	12	12	12	12
	SLO-2	Bravias lattices	diamond, graphite, alkaline graphite	surface area of nanomaterials	Impact testing	Examples in Analysis
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-5	SLO-1	Point defects	polymer compounds: Introduction	fabrication methods of nanomaterials	magnetic properties of materials: introduction	X-ray diffraction: Instrumentation, basic working principles
	SLO-2	Line defects: line	Examples and applications	Top down and bottom up approaches	Para magnetic properties	Examples in Analysis
S-6	SLO-1	Surface defects	band theory of solids	Classification of nanomaterials : 0D,1D and 2D nanomaterials	Ferro magnetic properties	Electron microscopy: SEM, Instrumentation, basic working principles
	SLO-2	Bulk defects	band theory of solids	0D nanomaterials examples and applications	anti-ferro magnetic properties	Examples in Analysis
S-7	SLO-1	synthetic approaches for crystalline functional materials: Chemical methods	Insulators	1D nanomaterials examples and applications	Ferri magnetic properties	Electron microscopy: TEM, Instrumentation, basic working principles
	SLO-2	synthetic approaches for crystalline functional materials: Chemical methods	semiconductors	2D nanomaterials examples and applications	Technological relevance of magnetic properties of materials with few examples	Examples in Analysis
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S9	SLO-1	synthetic approaches for crystalline functional materials: Chemical methods	Super conductivity	porous materials	Thermoelectric properties: Introduction	XPS: Instrumentation, basic working principles
	SLO-2	synthetic approaches for crystalline functional materials: Chemical methods	optical properties of materials	soft materials	dielectric properties	Examples in Analysis
S-10	SLO-1	synthetic approaches for crystalline functional materials: Physical methods	Band gap of materials and its correlation with optical properties	amorphous materials	Piezoelectric properties	Probe Analysis, AFM: Instrumentation, basic working principles
	SLO-2	synthetic approaches for crystalline functional materials: Physical methods	Concept of doping and different types of dopant materials	luminescent materials	Pyroelectric properties	Examples in Analysis
S-11	SLO-1	synthetic approaches for crystalline functional materials: Physical methods	Effect of doping on optical properties of materials	Discussion on a few examples of technologies developed using nanomaterials	ferroelectric effect	Peculiar examples of materials characterization
	SLO-2	synthetic approaches for crystalline functional materials: Physical methods	Devices based on optical properties of materials	Discussion on a few examples of technologies developed using nanomaterials	Technological relevance of electrical properties of materials with few examples	Peculiar examples of materials characterization
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					

Learning Resources	***1.*** A. R. West, Basic Solid State Chemistry, 2nd Ed., John Wiley &Sons Ltd., 1999 ***2.*** K. J. Klabunde, Nanoscale materials in Chemistry, Wiley Interscience, New York, 2001 ***3.*** C. Giacovazzo, Fundamentals of Crystallography, Oxford University Press, 2002. ***4.*** W. D. Callister and D. G. Rethwisch, Materials Science and Engineering: An Introduction,9th Ed., Wiley, 2013. ***5.*** D. J. Ward, Materials Science, Lerner Classroom, 2008

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. M. Arthanareeswari

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Course Code	PCY21D03T	Course Name	Advanced Polymer Science	Course Category	D	Discipline Elective Courses	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Gain exposure to the field of advanced polymer science																		
CLR-2 :	Understanding the structural requirements to exhibit liquid crystallinity and properties of different types of LCPs																		
CLR-3 :	Get knowledge on synthesis, properties and applications of different types of ionic polymers																		
CLR-4 :	Learn this course will develop skills on synthesis of conducting polymers and understand the significance and applications of conducting polymers.																		
CLR-5 :	Enrich the knowledge on biopolymers and biodegradable polymers and the basic aspects of polymer nanocomposites and their applications.																		
CLR-6 :	Correlate the structure and property of smart polymeric materials for advanced drug delivery, tissue engineering, medical devices, bioseparation, optical data storage, packaging and textile applications																		

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	Develop knowledge on advanced polymer science	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Learn about main-chain and side chain LCPs and their properties	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Get knowledge on ionic polymers for the preparation of polyelectrolyte complexes.	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Fabricate a device using suitable conducting polymeric material for rechargeable batteries, sensors, electrochemical actuators and electroluminescent.	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Identify the polymers for biomedical application and prepare nanocomposites for high temperature application.	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Design new smart polymeric material for advanced drug delivery, tissue engineering, medical devices, bioseparation, optical data storage, packaging and textile applications.	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to LCPs	Synthesis of ionic polymers	Synthesis of conducting polymers	Introduction to biopolymers and biodegradable polymers	Introduction to smart polymers
	SLO-2	Structural requirements to exhibit liquid	Synthesis of ionic polymers	Synthesis of conducting polymers	Introduction to biopolymers and biodegradable polymers	temperature-responsive polymers

Duration (hour)		12	12	12	12	12
		crystallinity				
S-2	SLO-1	Main-chain LCPs: thermotropic & lyotropic liquid crystals	properties of ionic polymers	properties of conducting polymers	polymers in medicines	pH-responsive polymers
	SLO-2	Various phases, study of phase transitions	applications of ionic polymers	polyacetylene	drug carriers & controlled drug release	photoresponsive polymers
S-3	SLO-1	properties of LC main-chain polymers	Ionic crosslinking	poly(p-phenylene vinylene) (PPV)	biodegradable polymers:starch-based polymers,	Magnetically & enzyme responsive polymers
	SLO-2	application of LC main-chain polymers	ion-exchange	poly(p-phenylene vinylene) (PPV)	poly(glycolic acid) (PGA) & polylactic acid (PLA)	shape memory polymers
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session
S-5	SLO-1	Side-chain LC polymers	ionomers based on polyethylene	polyheterocyclic and polyaromatic conducting polymers:	poly(lactic-co-glycolide) (PLGA)	smart hydrogels
	SLO-2	principles of synthesis	ionomers based on polyethylene	polyaniline	polycaprolactone (PCL)	smart hydrogels
S-6	SLO-1	structural features of side-chain LC polymers	ionomers based on polystyrene	polypyrrole & polythiophene	Applications of the pharmaceutical polymers: vinyl polymers	self-healing polymers
	SLO-2	properties of side-chain LC polymers	ionomers based on polytetrafluoroethylene	poly(3,4-ethylenedioxythiophene)(PEDOT)	cellulose ethers & polyesters	applications of smart polymers
S-7	SLO-1	application of side-chain LC polymers,	elastomeric ionomers	poly(p-phenylene sulfide)	silicones, polysaccharides and related polymers	drug delivery
	SLO-2	nematic and cholesteric LCPs	aromatic ionomers	poly(vinyl carbazole)	Polymer nanocomposites: an overview of nanoparticles	tissue engineering
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session
S-9	SLO-1	photochromic LCPs,	polymers with integral ions:	polypyrene	processing of nanomaterials	medical devices
	SLO-2	chiral-photochromic LCPs	halatotelechelic polymers (HTP's)	polyphenylene	processing of nanomaterials	medical devices
S-10	SLO-1	ionogenic LCPs & LC elastomers	polyethyleneimine (PEI) & ion exchange materials	Applications of conducting polymers: polymer rechargeable batteries	characterization of polymer nanomaterials	bioseparation
	SLO-2	photomechanical LC polymers	polyelectrolytic complexes	sensors	properties of polymer nanocomposite materials	optical data storage
S-11	SLO-1	LC block copolymers	biological ionic polymers	electrochemical actuators	polymer nanocomposites for high-temperature applications.	packaging & textiles application

Duration (hour)		12	12	12	12	12
	SLO-2	LC composites	inorganic ionic polymers	electroluminescent	current status, trends and future.	advancements in smart polymers.
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session

Learning Resources	**1.** X. Wang, Q. Zhou, Liquid Crystalline Polymers. N.J World Scientific: Singapore, 2004. **2.** Hendy B.N. Ionic polymers. In: Dyson R.W. (eds) Specialty Polymers. Springer, Boston, MA 1987. **3.** Matrin. T. Goosey, Plastics for Electronics, Elsevier Applied Science Publishers, 1985. **4.** M.J. Bowden and S.R. Turner, Polymers for High Technology, Electronics and Photonics, American Chemical Society 1987. **5.** Terje A. Skotheim, John Reynolds, Conjugated Polymers: Theory, Synthesis, Properties, and Characterization, 3rd Edition, CRC Press, 2006. **6.** David Jones, Pharmaceutical Applications of Polymers for Drug Delivery, iSmithers Rapra Publishing, 2004. **7.** Biopolymers, edited by Alexander Steinbüchel, Institute of Microbiology, University of Münster, WILEY-VCH, 2004. **8.** Joseph H. Koo, Polymer Nanocomposites, Processing, Characterization, and Applications, 2nd Edition,Mc Graw Hill, 2019. **9.** Maria Rosa Aguilar Julio San Román, Smart Polymers and Their Applications, 2nd Edition, Woodhead Publishing, 2019.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	1. Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	1. Dr. Samarendra Maji, SRMIST
	2. Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	2. Dr. Priyadip Das, SRMIST

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Course Code	PCY21S01J	Course Name	Fundamentals of Cheminformatics	Course Category	S	Skill Enhancement Courses	L	T	P	C
							1	0	2	2

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3
CLR-1 :	Enable them to learn the principles of computer aided chemical information tools			
CLR-2 :	Explore the data base search for the molecules and its access for the chemical reactions			
CLR-3 :	Explore about IUPAC names, design of molecules at different platforms.			
CLR-4 :	Develop strategies of drug design and target oriented receptor interaction study			
CLR-5 :	Strengthen the chemicals tools with computer aided learning with pharmacopeia study			
CLR-6 :	Stages of drug discovery and current state of art in the drug design process			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	Understand the basic principles of computer aided drug design through chemistry approaches.	2	75	60	H	H	H	-	H	H	M	H	H	-	H	H	H	H	H
CLO-2 :	Gain knowledge about the chemical databases	2	80	70	H	H	-	H	-	-	H	-	-	H	H	-	H	H	H
CLO-3 :	Understand the basic principles of design of molecules as chemical library	2	70	65	H	H	H	M	-	-	H	-	-	H	H	-	H	H	H
CLO-4 :	Acquaint the student with the fundamental concepts of drug discovery and different stages	2	70	70	H	-	H	H	H	-	M	-	-	H	H	-	H	H	H
CLO-5 :	Gain knowledge about the computer assisted synthesis and structure based library	2	80	70	-	H	-	M	-	H	H	-	-	H	H	-	H	H	H
CLO-6 :	Understand the principles of modeling tools and concepts in molecular modeling and pharmacokinetics	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Sequence, 2D, 3D structure	Analysis of CCDC structures and parameters	Chem Draw, Gaussian, Marvin Sketch	Combinatorial library design compound selection	Application of cheminformatics
	SLO-2	Types of chemical representation	Study with different examples and analysis	ORTEP, Chimera	combinatorial optimization approach	QSPR Drug design and Target identification and Validation
S2	SLO-1	**Practical:** Design of 2D and 3D structures	**Practical:** CCDC practice with examples	**Practical :** Chem bio draw with examples	**Practical:** PyMol software	**Practical:** Molecular modeling
	SLO-2					
S3	SLO-1	**Practical:** Developing data bases	**Practical:** CCDC practice with examples	**Practical :** Chem bio draw with examples	**Practical:** PyMol software with examples case study	**Practical:** Molecular modeling with examples
	SLO-2					

S-4	SLO-1	graphical representation	Crystallographic Open Database COD	RasMol, PyMol, Molecular Modeling Tools	Descriptor Analysis	lead finding and optimization
	SLO-2	Chemical data management	Structure design and search parameters	Structural Homology Modeling Tools Docking Tools and Screening Tools	Modeling toxicity	Examples with case study
S5	SLO-1 SLO-2	**Practical:** CIF creation and analysis with examples	**Practical:** Open data base creation of CIFs	**Practical:** Gaussian/Gauss view software with examples	**Practical:** Marvin Sketch software	**Practical:** QSPR and docking
S6	SLO-1 SLO-2	**Practical:** CIF creation and analysis with examples	**Practical:**Open data base creation of CIFs, ORTEP	**Practical :** Gaussian/Gauss view software with examples	**Practical:** Marvin Sketch software with examples	**Practical:** QSPR and docking with examples
S-7	SLO-1	Chemical markup languages	Protein Data Bank and design of PDB structure	Concepts in Molecular Modeling	Computer Assisted Synthesis and structure based library	Pharmacophore-Based Drug Design and model drugs
	SLO-2	IUCr Crystallographic Information Framework	PDB Ligand Explorer Chemspider, Other Data Bases	Molecular Mechanics Derivatives of molecular mechanics and Energy function	Development of drug, drug life cycle drug development time lines and stages of drug discovery	Structure-Based Drug design with examples
S-8	SLO-1 SLO-2	**Practical:** Graphical view of molecules	**Practical:** PDB data base	**Practical:** RasMol software	**Practical:** Marvin Sketch software with examples	**Practical:** Docking of durgs
S-9	SLO-1 SLO-2 SLO-2	**Practical:** Graphical view of molecules	**Practical:** Exploring Chemspider and its tools	**Practical:** Ras Mol software with examples case study	**Practical:** Marvin Sketch software with examples	**Practical:** Docking with examples

Learning Resources	1. Andrew R. Leach & Valerie J. Gillet, "An Introduction to Cheminformatics", Revised Edition, Springer Publication, 2007. 2. Johann Gasteiger, Dr. Thomas Engel, "Cheminformatics", Wiley-VCH Press, 2003. 3. Jurgen Bajorath, "Cheminformatics: Concepts, Methods and Tools for Drug Discovery", Humana Press, 2004. 4. Tudor. L.Oprea, "Cheminformatics in Drug Discovery", Wiley-VCH Press, 2005. 5. Silverman, Richard B., and Mark W. Holladay. The organic chemistry of drug design and drug action. Academic press, 2014. 6. Bajorath, Jurgen. Chemoinformatics for Drug Discovery. John Wiley & Sons, 2013.

	Bloom'sLevel of Thinking	**Continuous Learning Assessment (50% weightage)**								**Final Examination (50% weightage)**	
		CLA – 1 (10%)		**CLA – 2 (10%)**		**CLA – 3 (20%)**		**CLA – 4 (10%)#**			
		Theory	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**	**Theory**	**Practice**
Level 1	Remember Understand	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Level 2	Apply Analyze	40%	40%	50%	50%	50%	50%	50%	50%	50%	50%
Level 3	Evaluate Create	30%	30%	20%	20%	20%	20%	20%	20%	20%	20%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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Course Code	PCD21AE1T	Course Name	Professional Skills and Problem Solving	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre			Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1:	*Utilise success habits to enhance professionalism*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2:	Enable to solve problems and to crack competitive exams.																		
CLR-3:	Understand and master the mathematical concepts to solve types of problem																		
CLR-4:	Identify a logically sound and well-reasoned argument																		
CLR-5:	*Expertise in communication and problem-solving skills*																		
CLR-6:	*Develop problem solving skills with appropriate strategies*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	*Identify success habits and inculcate professional skills*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Grasp the approaches and strategies to solve problems with speed and accuracy*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*Collectively solve problems in teams and groups*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*Construe and solve an argument through critical thinking*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Acquire communication and problem- solving skills*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Apply problem solving techniques and skills*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		3	3	3	3	3
S-1	SLO-1	Personal profiling	Creative problem solving method	Case study analysis	Emotional Intelligence	Communication skills
	SLO-2	USP& Personal branding	Techniques	Case study analysis	Personal & social competence	Communication skills
S-2	SLO-1	Assumption and strengthening of an argument	Weakening and Inference of an argument	Conclusion and paradox of an argument	Main idea and structure of a passage	Tone and Style of a passage
	SLO-2	Assumption and strengthening of an argument	Weakening and Inference of an argument	Conclusion and paradox of an argument	Main idea and structure of a passage	Tone and Style of a passage
S-3	SLO-1	Arithmetic: Simple equations	Profit, Loss & Discount	Average	Percentage	Mixtures & alligation
	SLO-2	Equation 1 and equation 2	Interest calculation	Average	Percentage	Mixtures & alligation

Learning Resources	1.Arun Sharma-Quantitative aptitude for CAT, Tata McGraw Hill 2.Dinesh Khattar-The Pearson Guide to QUANTITATIVE APTITUDE for competitive examinations.	3.Manhatten Prep - GRE Reading Comprehension and Essays 4. Seven habits of highly effective people- Steven Covey 5. Manhattan Prep - Critical Reasoning Skills and Techniques

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA - 1 (10%)		CLA - 2 (10%)		CLA - 3 (20%)		CLA - 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Internal Experts	
1.Mr Ajay Zenne, Career Launcher, ajay.z@careerlauncher.com	Mr. P Priyanand, SRMIST	
	Mrs. Kavitha Srisarann, SRMIST	
2. Mr.Pratap Iyer, Study Abroad Mentors, Mumbai, pratap.iyer30@gmail.com	Mr. Harinarayana Rao, SRMIST	
	Dr. A Clement, SRMIST	

SEMESTER II

Course Code	POC21201T	Course Name	Spectroscopy and Applications in Organic chemistry	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Gain knowledge about basic spectroscopic techniques used in organic chemistry	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	Understand the fundamental and importance of UV and FTIR spectroscopy																		
CLR-3 :	Understand the fundamental and importance of Mass and NMR spectroscopy																		
CLR-4:	Provide basic understanding about the concepts involved in various chromatographic techniques																		
CLR-5:	Give insight about the advantages and limitations of spectroscopic techniques																		
CLR-6:	Provide basic understanding about the concepts involved in various chromatographic techniques																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Describe the physical and chemical changes that occur at the molecular level during a MS, IR, or NMR experiment.	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Identify different functional groups present in organic compounds using IR spectra.	2	80	70	H	H	H	H	L	H	L	H	M	H	H	M	H	H	H
CLO-3 :	Explain common terms in NMR spectroscopy such as chemical shift, coupling constant, and anisotropy, and describe how they are affected by molecular structure.	2	80	70	H	H	H	M	L	H	L	H	M	H	H	M	H	H	H
CLO-4 :	Analyze and interpret 1D- 1H and 13C NMR as well as 2D NMR to determine chemical structure of organic compounds.	2	70	65	H	H	H	M	L	H	H	L	L	H	H	L	H	H	H
CLO-5 :	Explain major fragmentation patterns of organic compounds using mass spectra	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Integrate all spectral data (MS, IR, and/or NMR) of a compound to elucidate the structure of an organic molecule.	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Ultraviolet spectroscopy: Introduction	Infrared spectroscopy: Units of frequency wave length	Mass spectroscopy: Basic Principles	NMR spectroscopy: Basics	SEPARATION TECHNIQUES: Solvent extraction and Ion exchange techniques
	SLO-2	Interaction of electromagnetic radiation with matter	wave number, molecular vibrations	Mass spectroscopy: Basic Principles	Larmor precession, resonance absorption	principles and applications
S-2	SLO-1	Absorption laws	factors influencing vibrational frequencies,	Instrumentation, The mass spectrometer	magnetic fields, shielding and chemical shifts	Chromatographic techniques
	SLO-2	Measurement of the spectrum, chromophores, standard	selection rules	Instrumentation, The mass spectrometer	chemical equivalence	adsorption chromatography

Duration (hour)		12	12	12	12	12
		works of reference				
S-3	SLO-1	Selection rules	The IR spectrometer	isotope abundances, the molecular ion, metastable ions	relaxation processes Solution state (1H, 13C)	thin layer chromatography
	SLO-2	electronic transitions in organic, and molecules and application to structure elucidation	Introduction	isotope abundances, the molecular ion, metastable ions	relaxation processes Solution state (1H, 13C)	gas chromatography
S-4	SLO-1	Applications of UV spectroscopy to Conjugated dines, trienes, unsaturated carbonyl compounds and aromatic compounds.	sampling techniques	Reactions of ions in gas phase - effect of isotopes	spin-spin coupling AX, AX2 and AXn systems	high performance liquid chromatography
	SLO-2	Applications of UV spectroscopy to Conjugated dines, trienes, unsaturated carbonyl compounds and aromatic compounds.	characteristic frequencies of organic molecules and interpretation of spectra	Reactions of ions in gas phase - effect of isotopes	Paramagnetic shifts and their applications	high performance liquid chromatography
S-5	SLO-1	Woodward -Fieser rules for the calculation of absorption maxima (Lamda max) for dienes and carbonyl compounds	Theory of IR spectroscopy	nitrogen rule, determination of molecular formula	Instrumentation	size exclusion chromatography
	SLO-2	Woodward -Fieser rules for the calculation of absorption maxima (Lamda max) for dienes and carbonyl compounds	Theory of IR spectroscopy	nitrogen rule, determination of molecular formula	Instrumentation	size exclusion chromatography
S-6	SLO-1	Fieser and Kuhn rules	various stretching and vibration modes for diatomic and triatomic molecules (both linear and nonlinear)	fragmentations and rearrangements - metastable ions - fragmentation of organic compounds	chemical shift, calculations of chemical shifts of aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbons	Supercritical fluid chromatography
	SLO-2	Effects of auxo chromes and effects of conjugation on the absorption maxima	various stretching and vibration modes for diatomic and triatomic molecules (both linear and nonlinear)	fragmentations and rearrangements - metastable ions - fragmentation of organic compounds	factors affecting chemical shifts	Supercritical fluid chromatography
S-7	SLO-1	Different shifts of absorption peaks (Batho chromic, hypsochromic, hypochromic)	various ranges of IR (Near, Mid, Finger print and Far) and their usefulness	Instrumentation, various methods of ionization (field ionization, field desorption, FAB, MALDI,)	APT, INEPT, DEPT	Electrophoresis
	SLO-2	Different shifts of absorption peaks (Batho chromic, hypsochromic, hypochromic)	various ranges of IR (Near, Mid, Finger print and Far) and their usefulness	Instrumentation, various methods of ionization (field ionization, field desorption, FAB, MALDI,)	Homo nuclear (13C13C) and Hetero nuclear (13C1H) coupling constants	Electrophoresis

Duration (hour)		12	12	12	12	12
S-8	SLO-1	Difference in the absorption spectra of organic and inorganic compounds and complexes	Instrumentation (Only the sources and detectors used in different regions)	different detectors - magnetic analyzer	2D NMR Techniques	Thermal methods of analysis - thermal methods of analysis and evolution of analytical data
	SLO-2	Difference in the absorption spectra of organic and inorganic compounds and complexes	Instrumentation (Only the sources and detectors used in different regions)	different detectors - magnetic analyzer	2D NMR Techniques	Thermal methods of analysis - thermal methods of analysis and evolution of analytical data
S-9	SLO-1	Instrumentation for single beam and double beam UV and VISIBLE spectrophotometers	sample preparation techniques (Gas, Liquid and solid)	ion cyclotron analyzer, Quadrupoule mass filter, time of flight (TOF)	General idea about two dimensional NMR spectroscopy	TGA - principles, instrumentation and applications
	SLO-2	Instrumentation for single beam and double beam UV and VISIBLE spectrophotometers	sample preparation techniques (Gas, Liquid and solid)	ion cyclotron analyzer, Quadrupoule mass filter, time of flight (TOF)	Correlation spectroscopy (COSY)-Homo COSY (1H1H)	TGA - principles, instrumentation and applications
S-10	SLO-1	Applications in organic molecule analysis	Qualitative analysis of alkanes, alkenes	Rules of fragmentation of different functional	TOCSY, Hetero COSY (HMQC, HMBC)	DTA - principles, instrumentation and applications
	SLO-2	Optical rotatory dispersion and circular dichroism: Phenomena of ORD and CD.	Qualitative analysis of alkanes, alkenes	Rules of fragmentation of different functional groups	Rules of fragmentation of different functional groups	DTA - principles, instrumentation and applications
S-11	SLO-1	Classification of ORD and CD Curves;	Qualitative analysis of carbonyl compounds	factors controlling fragmentation	Homo and Hetero nuclear 2D resolved spectroscopy	DSC - principles, instrumentation and applications
	SLO-2	Classification of ORD and CD Curves;	Qualitative analysis of carbonyl compounds	factors controlling fragmentation	Homo and Hetero nuclear 2D resolved spectroscopy	Types of errors
S-12	SLO-1	Cotton effect curves and their application to stereochemical problems	Organic functional group identification through IR spectroscopy	HRMS	NOESY and 2D-INADEQUATE experiments and their applications.	evaluation of analytical data statistical methods.
	SLO-2	The Octant rule and its application to alicyclic ketones.	Organic functional group identification through IR spectroscopy	HRMS	NOESY and 2D-INADEQUATE experiments and their applications.	evaluation of analytical data statistical methods

Learning Resources

1. Fundamentals of Molecular Spectroscopy. C. N. Banwell and E. M. McCash, Tata McGraw Hill publishing
2. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, Fourth Ed., Brooks/Cole Thomson Learning 2009.
3. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric identification of organic compounds, 7th edition, John Wiley, 2005.
4. Organic Spectroscopy, W. Kemp, 3rd edition, Macmillan, 2011.
5. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw Hill, 6th edition 2007.
6. Spectroscopic Methods in Organic Chemistry. Fourth Edition D.M. Williams and I. Fleming Tata - McGraw Hill, New Delhi, 1990. For all spectral methods except ORD and CD and ESR.
7. Organic Spectroscopy, Second Edition, W. Kemp, ELBS Macmillan, 1987 for ORD and CD.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	POC21202T	Course Name	Transformations in Organic Chemistry	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Introduce to the chemistry of the organoboron/silicon/tin	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	*Understand various C-C bond forming reactions and alkene chemistry*																		
CLR-3 :	*Gain knowledge of transition metal catalysis*																		
CLR-4 :	*Explore oxidation/reductions reactions as elegant synthetic methods*																		
CLR-5 :	*Introduce to the reactivity radical*																		
CLR-6 :	*Introduce to the chemistry and application of the polycyclic aromatic hydrocarbons (also heteroatom based)*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand boron, silicon and tin chemistry*	*2*	*75*	*60*	*H*	*H*	*H*	*-*	*H*	*H*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Comprehend alkene chemistry*	*2*	*80*	*70*	*H*	*H*	*-*	*H*	*-*	*-*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-3 :	*Understand transition metal based C-C bond formation*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*-*	*-*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-4 :	*Comprehend Oxidation and reduction methods in chemistry*	*2*	*70*	*70*	*H*	*-*	*H*	*H*	*H*	*-*	*M*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-5 :	*Understand reactivity and usefulness of radicals*	*2*	*80*	*70*	*-*	*H*	*-*	*M*	*-*	*H*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-6 :	*Know polyaromatic hydrocarbons and heteroatom based polyaromatic hydrocarbons and their applications*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Grignard reagents, Gilman reagentand other conjugate reactions	Metal-based and non-metal based oxidations of (a) alcohols to carbonyls	Catalytic hydrogenation (Heterogeneous: palladium/platinum/rhodium/nickel, etc.)	Introduction, natural sources, radical reactions in body	Origin of fused aromatics hydrocarbons, naphthalene, anthracene,
	SLO-2	Grignard reagents, Gilman reagent and other conjugate reactions	Metal-based and non-metal based oxidations of (a) alcohols to carbonyls	Catalytic hydrogenation (Heterogeneous: palladium/platinum/rhodium/nickel, etc.)	Introduction, natural sources, radical reactions in body	acenaphthene, phenanthrene, pyrene
S-2	SLO-1	Olefination and cyclopropanation reaction, Bayliss Hillman reaction	Corey-Kim oxidation, Dess-Martin oxidation	Catalytic hydrogenation (Homogeneous: Wilkinson). Noyori asymmetric hydrogenation)	Reactions involving free radical intermediates	aromatic stabilization, electron delocalization
	SLO-2	Olefination and cyclopropanation reaction, Bayliss Hillman reaction	Corey-Kim oxidation, Dess-Martin oxidation	Catalytic hydrogenation (Homogeneous: Wilkinson). Noyori asymmetric hydrogenation)	Reactions involving free radical intermediates	aromatic stabilization, electron delocalization

S-3	**SLO-1**	Organoboron compounds, synthesis of organoboranes, carbonylation	Swern oxidation, phenols (Fremy's salt, silver carbonate)	Metal based reductions using Li/Na/Ca in liquid ammonia	Generation of radical intermediates	synthesis
	SLO-2	Organoboron compounds, synthesis of organoboranes, carbonylation	Swern oxidation, phenols (Fremy's salt, silver carbonate)	Metal based reductions using Li/Na/Ca in liquid ammonia	Generation of radical intermediates	synthesis
S-4	**SLO-1**	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-5	**SLO-1**	other one-carbon homologation reactions, homologation via α-halo enolates,	Alkenes to epoxides (peroxides/per acids based),	Metal based reductions using sodium, magnesium, zinc	nucleophilic and electrophilic radicals	reactivity
	SLO-2	other one-carbon homologation reactions, homologation via α-halo enolates,	Introduction to asymmetric synthesis , Sharpless asymmetric epoxidation	Birch reduction, dehalogenation and deoxygenation	nucleophilic and electrophilic radicals	reactivity
S-6	**SLO-1**	stereoselective alkene synthesis, nucleophilic addition of allylic groups from boron compounds	Jacobsen epoxidation, Shi epoxidation	Hydride transfer reagents from Group III and Group IV in reductions. (i) NaBH4, triacetoxyborohydride	mechanisms of radical reactions, solvent and neighbouring group effects	heteroatomic polycyclic hydrocarbons, indole, benzofuran, benzothiophene, quinoline, phenanthroline
	SLO-2	stereoselective alkene synthesis, nucleophilic addition of allylic groups from boron compounds	Jacobsen epoxidation, Shi epoxidation	Hydride transfer reagents from Group III and Group IV in reductions. (i) NaBH4, triacetoxyborohydride	mechanisms of radical reactions, solvent and neighbouring group effects	heteroatomic polycyclic hydrocarbons, indole, benzofuran, benzothiophene, quinoline, phenanthroline
S-7	**SLO-1**	Organosilicon compounds, general features carbon-carbon bondforming reactions of organosiliconcompounds	alkenes to diols (manganese, osmium based), Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification	Hydride transfer reagents from Group IV in reductions. L-selectride, Kselectride	free radical substitutions at aliphatic substrates	aromatic stabilization, electron delocalization
	SLO-2	Organosilicon compounds, general features carbon-carbon bondforming reactions of organosiliconcompounds	alkenes to diols (manganese, osmium based), Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification	Hydride transfer reagents from Group IV in reductions. L-selectride, Kselectride	free radical substitutions at aliphatic substrates	aromatic stabilization, electron delocalization
S-8	**SLO-1**	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-9	**SLO-1**	acylation reactions, conjugate addition reactions.	alkenes to carbonyls with bond cleavage (manganese, osmium, ruthenium and lead based, ozonolysis)	Luche reduction, LiAlH4, DIBAL-H, and Red-Al, MPV reduction)	free radical substitutions at aromatic substrates	Synthesis
	SLO-2	acylation reactions, conjugate addition	alkenes to carbonyls with bond cleavage	Luche reduction, LiAlH4, DIBAL-H, and Red-Al,	free radical substitutions at	Synthesis

		reactions	(manganese, osmium, ruthenium and lead based, ozonolysis)	MPV reduction)	aromatic substrates	
S-10	SLO-1	Organotincompounds, synthesis of organostannanes,	alkenes to alcohols/carbonyls without bond cleavage (hydroboration-oxidation, etc.	Stereo/enantioselective reductions (chiral boranes, Corey-Bakshi-Shibata reduction)	cyclization of free radical intermediates, additions to C=N double bonds	Reactivity
	SLO-2	Organotincompounds, synthesis of organostannanes,	alkenes to alcohols/carbonyls without bond cleavage (hydroboration-oxidation, etc.	Stereo/enantioselective reductions (chiral boranes, Corey-Bakshi-Shibata reduction)	cyclization of free radical intermediates, additions to C=N double bonds	Reactivity
S-11	SLO-1	carbon-carbon bond forming reactions using tin reagents.	ketones to ester/lactones (Baeyer-Villiger)	Clemmenson and Wolff-Kishner reduction	fragmentation and rearrangement reactions, intramolecular functionalization by radical reactions	Applications of these compounds
	SLO-2	carbon-carbon bond forming reactions using tin reagents.	ketones to ester/lactones (Baeyer-Villiger)	Clemmenson and Wolff-Kishner reduction	fragmentation and rearrangement reactions, intramolecular functionalization by radical reactions	Applications of these compounds
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					

Learning Resources	**1.** J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 1st Ed., Oxford University Press, 2001. **2.** M.B. Smith & J. March, March's Advanced Organic Chemistry, 6thEd., John Wiley & Sons, New York, 2007. **3.** F.A. Carey and R.A. Sundberg, Advanced Organic Chemistry, Part A and Part B, 5thEd., Kluwer Academic/Plenum Publishers, New York, 2004. Unit-II: Chapter 9, 20, 22 (Clayden), Chapter 15,16, 18 (Smith), Chapter 7, 9 (Carey). Unit-III: Chapter 9, 20, 22 (Clayden), Chapter 19 (Smith). Unit-IV: Chapter 41 (Clayden), Chapter 19 (Smith), Chapter 5 (Carey). **4.** Clar, E. (1964). Polycyclic Hydrocarbons. New York, NY: Academic Press. LCCN 63012392.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	PCY21201T	Course Name	*Classical and Statistical Thermodynamics*	Course Category	*C*	*Professional Core Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the basic principles & concepts of classical thermodynamics.*																		
CLR-2 :	*Strengthen the knowledge of the students in numerical problems in classical & statistical thermodynamics.*																		
CLR-3 :	*Understand the basic concepts of Born-Oppenheimer approximation & Partition function.*																		
CLR-4 :	*Acquaint the student with the fundamental concepts of statistical thermodynamics and its applications.*																		
CLR-5 :	*Acquaint the student with the fundamental concepts of Non-equilibrium thermodynamics.*																		
CLR-6 :	*Understand the thermodynamic feasibility of a process.*																		

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	*Understand the basic principles & concepts of classical thermodynamics.*	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquaint students with the numerical problems in classical & statistical thermodynamics.*	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	*Gain the knowledge about concepts & approach of statistical thermodynamics.*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	*Understand the concept of Born-Oppenheimer approximation & Partition function.*	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge of Non-equilibrium thermodynamics, phenomenological equations & Onsager relations.*	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6 :	*Understand the thermodynamic feasibility of a process.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		**12**	**12**	**12**	**12**	**12**
S-1	**SLO-1**	First law of thermodynamics & concept of work	Thermodynamic equation of state	Introduction of Statistical thermodynamics; Aim	Thermodynamic functions in terms of the partition function	Basics of Non-equilibrium thermodynamics
	SLO-2	Heat, work & internal energy concept	Applications of Maxwells relation	Macro and microstates	Continued. internal energy, entropy, Helmholtz function, pressure, Gibbs function, residual entropy	Reversible, metastable process, dissipation of energy
S-2	**SLO-1**	enthalpy and heat capacities	Internal pressure in case of ideal and non-ideal gas	Thermodyanmic probability, apriory probability	Continue. monoatomic and diatomic gases	Steady state process concept
	SLO-2	Numerical problems	Extensive & intensive properties	Boltzmann plank equation and concept	equilibrium constant & partition function; van't Hoff isotherm correlation	near equilibrium process; general theory

Duration (hour)		12	12	12	12	12
S-3	SLO-1	second law of thermodynamics	thermodynamics of systems of variable composition	Distinguishability and particles	Continue: Applications such as dissociation of diatomic molecule	Continued
	SLO-2	Concept of Entropy & Physical significance	partial molar quantities & examples	ensembles (microcanonical, grand canonical and canonical)	Isotope effects in terms of partition function	Phenomenological laws and equations
S-4	SLO-1	Direction of spontaneous change and dispersal of energy; Feasibility of reaction	partial molar volume & chemical potential	Canonical ensemble, Maxwell-Boltzmann statistics & most probable distribution	molecular interpretation of the basic laws of thermodynamics	Coupled flows
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Cyclic process & Carnot cycle	Gibbs-Duhem equation	Concept of Stirling approximation and Lagranges undetermined multipliers	average energies and equipartition principle	Linear and Onsager phenomenological coefficients
	SLO-2	Work done in a cyclic process	Gibbs-Duhem equation & application	Quantum mechanical statistics viz. Fermi-Dirac; conditions, concept of fermions	Canonical partition function	Onsager relations for coupled flows
S-6	SLO-1	Work done in a cyclic process	Dependence of chemical potential on P & T	Quantum mechanical statistics viz. Fermi-Dirac; conditions, concept of fermions	heat capacity of monoatomic gases	conservation of mass and energy in closed and an open system
	SLO-2	efficiency of heat engine	Relationship with partial molar entropy	Bose-Einstein statistics; conditions & concept of Bosons	theories of heat capacities of solids; Dulong Petit's law	conservation of mass and energy in closed and an open system
S-7	SLO-1	coefficient of performance of heat engine	Concept of fugacity	Concept of degeneracy	Einstein's theory of heat capacities of solids; limitations	entropy production in chemical reactions, especially spontaneous process
	SLO-2	Gibbs function & Helmholtz function	experimental determination of fugacity of real gases	negative absolute temperatures & population inversion	Einstein's theory of heat capacities of solids; limitations	entropy production and entropy flow in open systems
S-8	SLO-1	Maximum work done and net work done	Fugacity in case of liquid & solid	Molecular partition function concept & numerical problems	Debye theory of heat capacities of solids nuclear spin statistics	entropy production and entropy flow in open systems
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Gibbs-Helmholtz equation & applications	Nernst-Heat theorem	evaluation of the partition function; translational & numerical problems	nuclear spin statistics	transformation properties of rates and affinities
	SLO-2	Gibbs equations and derivations	third law of thermodynamics	Rotational partition function & numerical problems	statistical basis of entropy of H_2 gas & ortho and para nuclear states	Onsager's theory
S-10	SLO-1	Maxwell relations	absolute entropies	Vibrational partition function & numerical problems	statistical basis of entropy of H_2 gas & ortho and para nuclear states	Onsager's theory
	SLO-2	Mathematical approach: partial differential	Determination of absolute entropies	Tutorial	calculation of entropy in terms of ortho para ratio	irreversible thermodynamics and biological systems

Duration (hour)		12	12	12	12	12
S-11	SLO-1	Entropy change in various processes	exceptions to third law	Electronic partition function; term symbols of ground state of atoms, degeneracy	residual entropy of H_2 at 0 K	irreversible thermodynamics and biological systems
	SLO-2	Isothermal, reversible-irreversible, adiabatic processes	unattainability of absolute zero; residual entropy	Nuclear partition function	Brief of applications of quantum statistical approach	oscillatory reactions
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session

Learning Resources	1. K. Rajaram and J.C. Kuriacose, *Thermodynamics For Students of Chemistry*, 2nd Ed., S.L.N. Chand and Co, Jalandhar,1986. 2. I.M. Klotz and R.M. Rosenberg, *Chemical thermodynamics*, 6th Ed., W.A. Benjamin Publishers, California, 1972. 3. P. W. Atkins, J. De Paula, *Physical Chemistry,* 9thEd., Oxford University Press, Oxford, 2010 4. M.C. Gupta, *Statistical Thermodynamics*, New Age International, Pvt. Ltd, New Delhi, 1995. 5. B. R. Puri, L.R. Sharma and M.S. Pathania, *Principles of Physical Chemistry*, 46th Ed., Vishal Publishing Co., 2014.

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. Bhalchandra Kakkade, SRMIST
	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. M. Arthanareeswari, SRMIST

Course Code	PCY21202J	Course Name	*Main Group Elements and Nuclear Chemistry*	Course Category	*C*	*Professional Core Course*	L	T	P	C
							2	0	4	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3
CLR-1 :	*Provide specialized knowledge in the area of periodicity in Chemistry*			
CLR-2 :	*Provide the background for understanding fundamental principles behind the classification and nature of elements*			
CLR-3 :	*Provide knowledge of numerous useful compounds that can be obtained from the main group elements*			
CLR-4 :	*Understanding the importance and practical utility of compounds derived from main group elements*			
CLR-5 :	*Provide in-depth knowledge, understanding and hands-on training on their syntheses, reactivity and properties*			
CLR-6 :	*Understanding the various nuclear phenomena, underlying chemistry and physics*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	*Familiar with the knowledge of chemical periodicity and classification of elements*	*2*	*75*	*60*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Knowledge of library of compounds obtained from main group elements, underlying chemistry and their practical utility*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Skill and efficiency in inorganic syntheses of useful compounds*	*2*	*70*	*65*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Familiar with the scope and societal utility of nuclear science*	*2*	*70*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*
CLO-5 :	*Implicate the knowledge and understanding into research on novel technologies.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Knowledge and awareness of nuclear technologies in medical and energy sectors.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		18	18	18	18	18
S-1	SLO-1	Description and chemical properties of s-block metals	Polymorphism of carbon, catenation and heterocatenation,	Boron oxides and oxoacids, boron sesquioxide, borax, sodium peroxoborates	Boronhydrides, reaction with ammonia, hydroboration,	Composition of nucleus, nuclear forces, packing fraction, nuclear density,
	SLO-2	reaction with water, air, nitrogen	Polymorphism of carbon, phosphorus and sulfur	organic compounds containing boron-oxygen bonds	structure of boranes, borohydrides and their uses,	Mass defect, binding energy of the nucleus
S-2	SLO-1	Applications of their compounds, Oxides, hydroxides	carbides, salt like carbides,	B-N compounds - aminoboranes, borazines, polyborazines,	boron and multicentre bonding, boron cages,	nuclear models, concept of nuclear spin.
	SLO-2	peroxides, superoxides	interstitial carbides, covalent carbides,	boroxines and boron nitrides,	vacuum technique of synthesis, lower and higher boranes	Radioactivity, radioactive disintegration, radioactive decay and

Duration (hour)		18	18	18	18	18
					reactions,	half-life
S-3-6	SLO-1	Semi-micro qualitative analysis - description of the course	Analysis of cations of Li, Na, Ca, Ba, Sr	Analysis of cations of Li, Na, Ca, Ba, Sr	Analysis of cations of Co, Ni, Cu, Zn, Cd, Pb	Analysis of cations of Co, Ni, Cu, Zn, Cd, Pb
	SLO-2					
S-7	SLO-1	preparation and properties, oxo salts, carbonates	properties and structures of ortho, pyro, cyclic, chain, sheet, three dimensional silicates,	chemistry of P-N compounds - synthesis and reactivity	structure and bonding, topological treatment,	Geiger-Nuttall rule, radioactive equilibrium, steady state, transmutation of elements,
	SLO-2	bicarbonates, nitrates, and halides	silicates in technology-alkali silicates, ceramics, glass,	Phosphazene and its polymers	Wade's rule, styx numbers,	group displacement rule, nuclear stability, radioactive series
S-8	SLO-1	anomalous behavior of Li and Be	organosilicones, preparation, structures, and applications.	theories of bonding, electronic structure and and aromaticity	carboranes, metallocarboranes, other hetero atom boron derivatives.	isotopes, isobars, isotones, separation of isotopes,
	SLO-2	complexes of s-block metals - with crown ethers	Synthesis, structure and bonding in polyanions of phosphorous	--do--	Metal atom cluster, di, tri, tetra, and hexanuclearity metal clusters	artificial radioactivity, induced radioactivity, transuranic elements,
S-9-12	SLO-1	Analysis of cations and anions of Se, Te, Mo,	Analysis of cations and anions of As, Sb,	Analysis of cations of Ce, Be, Th,	Analysis of cations of Zr, Ti, V, Cr, Mn,	Analysis of cations of Zr, Ti, V, Cr, Mn,
	SLO-2					
S-13	SLO-1	complexes with cryptands.	vanadium, chromium, molybdenum and tungsten,	Synthesis and reactivity of S-N compounds	cluster structure based on electron counting schemes,	nuclear fission, nuclear fusion.
	SLO-2	Applications in chemical synthesis,	Oxides and oxyacids of Se and Te	S_4N_4, S_2N_2, and $S_3N_3Cl_3$	capping rule, isoelectronic and isolobal analogy, relationship between fragments	Detectors: scintillation counter, gas ionization chamber, proportional counter, Cerenkov counter,
S-14	SLO-1	Organometallic compounds of Li, Mg and Be	Structure and properties of interhalogen compounds [ClF_3, ClF_5, BrF_5, IF_5, IF_7], poly halides	poly thiazyl (SN)x compounds	isolobal relationships between main-group and transition metal fragments	activation analysis, isotopic dilution technique, radiometric titration.
	SLO-2	reactivity and bonding.	psuedohalogens, [cyanide, thiocyanate and azide] and xenon compounds.	properties and applications of S-N compounds	dn-pn bonding, examples.	applications of radioactivity in mankind
S-15-18	SLO-1	Analysis of unknown salt	Analysis of unknown mixture salts	Analysis of unknown mixture salts	Analysis of unknown mixture salts	Analysis of unknown mixture salts
	SLO-2					

Learning Resources	
	1. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 5th Ed., W. H. Freeman and Co, London, **2. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochman, Advanced Inorganic Chemistry, 6th Ed., John Wiley, New York, 1999.** **3. J. D. Lee, Concise Inorganic Chemistry, 5th Ed. Wiley-India, 2008** **4. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, Pergamon Press, Oxford, 1984.** **5. H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Ed., New Age International, New Delhi, 1995.** **6. Vogel's Inorganic Qualitative Analysis, 7th Impression by G. Svehla, Pearson Education, New Delhi, 2009**

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
	Understand										
Level 2	Apply	40%	40%	50%	50%	50%	50%	50%	50%	50%	50%
	Analyze										
Level 3	Evaluate	30%	30%	20%	20%	20%	20%	20%	20%	20%	20%
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. Goutham Kumar Kole, SRMIST
	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. T. Senthil Andavan, SRMIST

Course Code	POC21203T	Course Name	Heterocyclic Chemistry and Total Synthesis of Natural Products	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

CLR-1 :	Give the student a broad understanding of the major classes of heterocyclic compounds
CLR-2 :	Make the student learn nomenclature, structure, properties, syntheses, and reactions of non-aromatic heterocycles
CLR-3 :	Enable the student to learn nomenclature, structure, properties, syntheses, and reactions of aromatic heterocycles
CLR-4 :	Learn various nucleophilic, substitution and electrophilic reactions in heterocyclic chemistry
CLR-5 :	Learn the importance of naturally occurring alkaloids, terpenoids and antibiotics
CLR-6 :	Learn the concepts of retrosynthetic approach, the art and science of total synthesis

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1 :	Understand the structures, syntheses, reactions, and properties of the major classes of heterocyclic compounds	2	75	60	H	H	H	L	H	H	M	H	H	L	H	H	H	H	H
CLO-2 :	Predict the nucleophilic and electrophilic reaction mechanisms, catalyst and rearrangements reactions	2	80	70	H	H	L	H	L	L	H	L	L	H	H	L	H	H	H
CLO-3 :	Able to draw mechanisms for reactions involving heterocycles as starting materials, intermediates and products, and to propose syntheses of heterocycles from the major classes	2	70	65	H	H	H	M	L	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Explain the classification of alkaloids, terpenoids and their importance and uses	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Evaluate and propose syntheses of complex natural products	2	80	70	L	H	L	M	L	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Learn the broad class of synthetic transformations including asymmetric transformation, coupling reactions, selective redox reactions in the total synthesis	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Nomenclature of heterocyles: Common Name Nomenclature	Tautomerism in aromatic heterocycles and factors	Synthesis of azirines	Reactions of pyrrole, furan and thiophene	Total synthesis of forskolin
	SLO-2	The replacement nomenclature	General trends in the reactivity of aromatic heterocycles	Synthesis of azirines	Reactions of pyrazole	Total synthesis of forskolin
S-2	SLO-1	The Hantzsch-Widman nomenclature for Monocyclic heterocycles	Strain in small ring heterocycles	Synthesis of pyrrole, furan and thiophene	Reactions of imidazole, oxazole and thiazole	Importance and uses of reserpine

Duration (hour)		12	12	12	12	12
	SLO-2	The Hantzsch-Widman nomenclature for Fused heterocycles	Consequences of Bond angle strain in small ring heterocycles	Synthesis of pyrrole, furan and thiophene	Reactions of pyrimidine and pyrazine	Retrosynthetic synthesis of reserpine
S-3	SLO-1	The Hantzsch-Widman nomenclature for bridged heterocycles	Consequences of Bond angle strain in small ring heterocycles	Synthesis of pyrazole	Reactions of benzofuran, indole and benzothiophene	Woodward's synthesis of reserpine
	SLO-2	Effect of heteroatoms on organic reactions in comparison with carbogenic compounds-Physical Properties	Conformation of six-membered heterocycles	Synthesis of pyrazole	Reactions of of pyridine, quinoline and isoquinoline	Woodward's synthesis of reserpine
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial Synthesis of imidazole	Tutorial	Tutorial
S-5	SLO-1	Effect of heteroatoms on organic reactions Chemical Properties	Barrier to ring inversion	Synthesis of imidazole	Synthesis of six membered rings containing two heteroatoms	Importance and uses of cholesterol
	SLO-2	Heterocycles in organic synthesis	Pyramidal inversion	Synthesis of imidazole	Reactions of synthesis of six membered rings containing two heteroatoms	Woodward's synthesis of cholesterol
S-6	SLO-1	Heterocycles in biomolecules	1,3-diaxial interactions	Synthesis of oxazole and thiazole	Introduction and importance of natural products	Woodward's synthesis of cholesterol
	SLO-2	Oxidation in heterocyclic chemistry	Factors affecting anomeric effect	Synthesis of oxazole and thiazole	Introduction to Retrosynthetic analysis of antibiotics	Corey's synthesis of prostaglandins (E2, F2α),
S-7	SLO-1	Reductions in heterocyclic chemistry	Consequences of anomeric effect	Synthesis of pyrimidine and pyrazine	Retrosynthetic analysis of antibiotics: Penicillin	Corey's synthesis of prostaglandins (E2, F2α),
	SLO-2	Aromatic heterocycles: classification	Double anomeric effect,Rabbit-ear effect (lone pair-lone pair interactions)	Synthesis of pyrimidine and pyrazine	Total synthesis of Penicillin	Importance and uses of taxol
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-9	SLO-1	Criteria of aromaticity	Repulsive-gauche effect (hockey-sticks effect)	Synthesis of benzofuran, indole and benzothiophene	Alkaloids: Morphine. importance and uses	Retrosynthetic approach of taxol
	SLO-2	Structural Criteria: Bond length	Hydrogen bonding and intermolecular nucleophilic, electrophilic interactions	Synthesis of benzofuran, indole and benzothiophene	Retrosynthetic analysis of morphine	Nicolaou's synthesis of taxol
S-10	SLO-1	Electronic Criteria: Dipole moment	Basic principles of heterocycle synthesis	Synthesis of pyridine, quinoline and isoquinoline	Total synthesis of morphine	Nicolaou's synthesis of taxol
	SLO-2	Energetic Criteria: Delocalization energy	Baldwin's Rule	Synthesis of pyridine, quinoline and isoquinoline	Total synthesis of morphine	Danishefsky's synthesis of indolizomycin
S-11	SLO-1	Energetic Criteria: Dewar Resonance Energy	Synthesis of aziridines	Reactions of azirines	Terpenes: Forskolin. Importance and uses	Danishefsky's synthesis of indolizomycin
	SLO-2	Magnetic Criteria: Ring current and chemical shifts in ^{1}H NMR-spectra	Reactions of aziridines	Reactions of azirines	Retrosynthetic analysis of forskolin	Takasago synthesis of menthol

Duration (hour)		12	12	12	12	12
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial

Learning Resources	1. T. L. Gilchrist, Heterocyclic Chemistry, 3rd Ed., Prentice Hall, 1997. 2. A. R. Katritzky, and C. W. Rees, Comprehensive Heterocyclic Chemistry, Pergamon Press, 1996. 3. R. R. Gupta, M. Kumar, and V. Gupta, Heterocyclic Chemistry, Vo1.1-3, Springer Verlag, 2008. 4. D. T. Davies, Aromatic Heterocyclic Chemistry, Oxford Chemistry Primers, 1992. 5. K. C. Nicolaou, Classics in total synthesis, Wiley, 1996.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. P. Gopinath, SRMIST

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Course Code	POC21D02T	Course Name	Asymmetric and Enzymatic Synthesis	Course Category	D	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Introduce the students with the most updated developing area in Organic Synthesis.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	Enable them to learn idea of asymmetric synthesis																		
CLR-3 :	*Enable them to think of multistep synthesis of important organic molecules*																		
CLR-4 :	*Help the understand the role of organocatalysts in organic synthesis*																		
CLR-5 :	*Explore them to the enzyme structure and reactivity*																		
CLR-6 :	Learn about the applications of enzymes in organic synthesis.																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	Understand the methods and fundamentals of asymmetric synthesis	*2*	*75*	*60*	*H*	*H*	*H*	*-*	*H*	*H*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the use of organocatalysts in organic synthesis*	*2*	*80*	*70*	*H*	*H*	*-*	*H*	*-*	*-*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-3 :	*Understand the preparation and use of NHC*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*-*	*-*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-4 :	Comprehend biocatalysis and their role in organic synthesis	*2*	*70*	*70*	*H*	*-*	*H*	*H*	*H*	*-*	*M*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-5 :	Gain knowledge about the different organocataly	*2*	*80*	*70*	*-*	*H*	*-*	*M*	*-*	*H*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-6 :	*Plan the multistep organic synthesis of important optically active molecules*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Asymmetric synthesis: chiral auxiliaries, methods of asymmetric induction	Introduction to organocatalysis	Carbenes as organocatalysts	Introduction to biocatalysts, advantages and disadvantages of biocatalysts	Biocatalytic oxidation reactions of alcohols and aldehydes
	SLO-2	Asymmetric synthesis: chiral auxiliaries, methods of asymmetric induction	Introduction to organocatalysis	Carbenes as organocatalysts	Introduction to biocatalysts, advantages and disadvantages of biocatalysts	Biocatalytic oxidation reactions of alcohols and aldehydes
S-2	SLO-1	substrate, reagent and catalyst controlled reactions	Lewis acid catalysis	types of different NHCs and their synthesis	isolated enzymes vs. whole cell systems, brief overview of structure of enzymes	biocatalytic carbon-carbon bond formations, aldol reaction, Michael-type additions,
	SLO-2	substrate, reagent and catalyst controlled reactions	Lewis acid catalysis	types of different NHCs and their synthesis	isolated enzymes vs. whole cell systems, brief overview of structure of enzymes	biocatalytic carbon-carbon bond formations, aldol reaction, Michael-type

Duration (hour)		12	12	12	12	12
						additions,
S-3	SLO-1	determination of enantiomeric and diastereomeric excess, enantiodiscrimination,	Lewis base catalysis	NHC catalyzed umpolung	mechanistic aspects of enzyme catalysis	thiamine-dependant benzoin condensation
	SLO-2	determination of enantiomeric and diastereomeric excess, enantio discrimination,	Lewis base catalysis	NHC catalyzed transesterification reactions	mechanistic aspects of enzyme catalysis	thiamine-dependant benzoin condensation
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-5	SLO-1	resolution - optical and kinetic	iminium catalysis	oxidative NHC catalysis	classification and nomenclature	cyanohydrin formation, amino transfer reaction
	SLO-2	resolution - optical and kinetic	iminium catalysis	oxidative NHC catalysis	classification and nomenclature	cyanohydrin formation, amino transfer reaction
S-6	SLO-1	asymmetric oxidation [epoxidation: Sharpless, Jacobsen, Shi)	enamine catalysis	cooperative catalysis with metal catalysts	coenzymes, enzyme sources	halogenations and dehalogenations
	SLO-2	asymmetric oxidation [epoxidation: Sharpless, Jacobsen, Shi)	enamine catalysis	cooperative catalysis with metal catalysts	coenzymes, enzyme sources	halogenations and dehalogenations
S-7	SLO-1	dihydroxylation (Sharpless)]	Bronsted acid catalysis	cooperative catalysis with other organocatalysts	biocatalysed hydrolytic reactions, hydrolysis of amides, esters	enzymes in organic solvents, ester synthesis, lactone synthesis
	SLO-2	dihydroxylation (Sharpless)]	Bronsted acid catalysis	cooperative catalysis with other organocatalysts	biocatalysed hydrolytic reactions, hydrolysis of amides, esters	enzymes in organic solvents, ester synthesis, lactone synthesis
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					
S-9	SLO-1	asymmetric reduction (Noyori, Corey, Pfaltz)	Bronsted base catalysis	homo and cross benzoin type reactions	Biocatalytic hydrolysis of epoxides and nitriles	amide synthesis, peptide synthesis
	SLO-2	asymmetric reduction (Noyori, Corey, Pfaltz)	Bronsted base catalysis	homo and cross benzoin type reactions	Biocatalytic hydrolysis of epoxides and nitriles	amide synthesis, peptide synthesis
S-10	SLO-1	stereoselective aldol reactions (Cram's rule and Felkin Anh models)	quaternary ammonium salts as catalyst and phase transfer catalyst	Stetter reaction, enolate chemistry, homoenolate derived reactions	biocatalytic reduction reactions, recycling of cofactors	artificial enzyme mimics,
	SLO-2	stereoselective aldol reactions (Cram's rule and Felkin Anh models)	quaternary ammonium salts as catalyst and phase transfer catalyst	Stetter reaction, enolate chemistry, homoenolate derived reactions	biocatalytic reduction reactions, recycling of cofactors	artificial enzyme mimics,
S-11	SLO-1	auxillary controlled stereoselection, Evans oxazolidones.	Physical influence in asymmetric synthesis	addition to ketenes and analogs	reduction of aldehydes, ketones and C=C bonds	catalytic antibodies
	SLO-2	auxillary controlled stereoselection, Evans oxazolidones.	Physical influence in asymmetric synthesis	addition to ketenes and analogs	reduction of aldehydes, ketones and C=C bonds	catalytic antibodies

Duration (hour)		12	12	12	12	12
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2					

Learning Resources	
	1. R. Gawley and J. Aube, Principles of Asymmetric Synthesis, 2nd Ed., Elsevier, 2012. 2. K. Faber, Biotransformations in Organic Chemistry, 6th Ed., Springer, 2011. 3. Seayad, Jayasree, and Benjamin List. "Asymmetric organocatalysis." Organic & biomolecular chemistry 3.5 (2005): 719-724. 4. Hopkinson, Matthew N., et al. "An overview of N-heterocyclic carbenes." Nature 510.7506 (2014): 485-496. 5. Flanigan, Darrin M., et al. "Organocatalytic reactions enabled by N-heterocyclic carbenes." Chem. Rev 115.17 (2015): 9307-9387.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. Anjan Bedi SRMIST
	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. Gopal Chandru Senadi, SRMIST

Course Code	PCY21D04T	Course Name	*Nanomaterials and Nanochemistry*	Course Category	*D*	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-1 :	*Acquire sound knowledge about nanochemistry*																		
CLR-2 :	*Understand the fundamentals of nanochemistry*																		
CLR-3 :	*Learn the synthesis of nanomaterials*																		
CLR-4 :	*Gain deep knowledge about the analytical techniques to characterize the nanomaterials*																		
CLR-5 :	*Learn carbon nanostructures and their synthesis*																		
CLR-6 :	*Learn the application of nanomaterials in catalysis*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the phenomenon underlying the nanomaterials based products in use*	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Identify the suitable methods for the synthesis of any specific nanomaterial*	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	*Guide for the suitable technique to characterize nanomaterial and understand the obtained results*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	*Synthesize and carbon nanomaterials and modify them and design based on the requirement*	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	*Understand the parameters responsible for the catalytic efficiency of nanomaterials and tune them for better performance*	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6 :	*Design a specific nanomaterial, synthesize them, characterize and modify based on the application focused*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to nanoscience and nanotechnology	Basics of nanofabrication methods	Discussion on various techniques available for characterizing the nanomaterials for their size, shape, morphology	Bonding in carbon, new carbon structures	Nanocatalysis: fundamentals
	SLO-2	Introduction to nanoscience and nanotechnology	top-down, bottom-up approaches	Scanning electron microscope (SEM) and examples	Bonding in carbon, new carbon structures	homogeneous vs heterogeneous catalysis
S-2	SLO-1	discussion on various phenomenon at nanoscale	gas phase, liquid phase, solid phase synthesis	Discussion on various techniques available for characterizing the nanomaterials for their size, shape, morphology	carbon clusters	effect of surface area, effect of particle size
	SLO-2	discussion on nano size	self-assembly, templated synthesis	Transmission electron microscope(TEM), examples and a comparison with SEM	discovery of C60	shape and morphology
S-3	SLO-1	discussion on nano shape	Sol-gel synthesis	Discussion on various techniques available for	alkali doped C60,superconductivity	effect of composition

Duration (hour)		12	12	12	12	12
				characterizing the nanomaterials for crystalline phase	in C60	
	SLO-2	discussion on nano surface	Synthesis through electrodeposition	X-ray powder diffraction (XRD)	larger and smaller fullerenes	bimetallic system etc
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-5	SLO-1	Discussion on surface energy	fundamentals of nanoparticle formation	Discussion on various techniques available for characterizing the nanomaterials for oxidation states	carbon nanotubes: synthesis	nanomaterials for photo-catalysis: Introduction and overview
	SLO-2	Discussion on surface stabilization	Thermodynamic approach, supersaturation	X-ray photoelectron spectroscope (XPS)	single walled carbon nanotubes	dye degradation
S-6	SLO-1	characteristic length	Nucleation and growth of nanoparticles	textural properties (surface area, pore volume, pore size)	structure and characterization of carbon nanotubes	organic transformations
	SLO-2	self-assembly	homo vs hetero nucleation	N2 sorption techniques for textural properties of the materials	structure and characterization of carbon nanotubes	plasmon assisted photo-catalysis
S-7	SLO-1	defects	Synthesis of nanoparticles, Metallic, semiconducting	Thermal analysis	mechanism of formation	band gap tuning in nanomaterials
	SLO-2	size quantization	Synthesis of nanoparticles, Metallic, semiconducting	TGA	chemically modified carbon nanotubes	band gap tuning and photocatalytic performance
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-9	SLO-1	surface plasmon	Synthesis of nanoparticles: quantum dots, oxides, hybrids	Solid state NMR for characterizing functionalized materials.	Doping, functionalizing nanotubes	Nanomaterials for water splitting
	SLO-2	conductivity	Synthesis of nanoparticles: quantum dots, oxides, hybrids	Peculiar Examples of materials characterized using NMR	application of carbon nanotubes	Nanomaterials for water splitting
S-10	SLO-1	tunneling,	micelles and microemulsion as templates for synthesis	Scanning tunnelling microscope (STM)	Carbon nanowires	nanomaterials for CO_2 capture
	SLO-2	magnetism	0D, 1D and 2D nanoparticles,	Examples of materials characterized using STM	synthetic strategies: gas phase and solution phase growth	nanomaterials for CO_2 capture
S-11	SLO-1	defects	core-shell nanoparticles	Atomic force microscope (AFM)	growth control	nanomaterials for CO_2 conversion
	SLO-2	defects	special nanoparticles, shaped nanoparticles	Atomic force microscope (AFM)	Properties of carbon nanowires	nanomaterials for CO_2 conversion
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial

Learning Resources	**1.** C. N. R.Rao, A. Muller and A. K. Cheetam, (Eds) (2004): The Chemistry of Nanomaterials, **2.** C. P. Poole, and Jr. F. J. Owens,Introduction to Nanotechnology, Wiley Interscience, New Jersey. 2003. **3.** K. J. Klabunde, Nanoscale materials in Chemistry, Wiley- Interscience, New York, 2001 **4.** T. Pradeep, Nano: The Essentials in Understanding Nanoscience and Nanotechnology, Tata McGraw Hill, New Delhi, 2007. **5.** T. Tang and P. Sheng, Nano Science and Technology - Novel Structures and Phenomena, Taylor & Francis, New York, 2004 **6.** U. Heiz, and U. Landman,Nanocatalysis, Springer, New York, 2006

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. M. Arthanareeswari, SRMIST

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Course Code	POC21S01L	Course Name	Organic Chemistry Practical: Functional group analysis and synthesis	Course Category	S	Skill Enhancement Course	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3
CLR-1 :	Gain exposure to the practical knowledge of organic reactions			
CLR-2 :	Gain insight about the setting up a basic reaction for synthesis of simple compounds			
CLR-3 :	Learn about the analysis of different organic functional groups			
CLR-4 :	Gain knowledge about the structural elucidation of synthesized compounds using different techniques			
CLR-5 :	Know how to maintain the record of experiments conducted			
CLR-6 :	Learn strategies for the synthesis of drug molecules			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	Understand different purification techniques in organic chemistry like recrystallization, distillation, steam distillation and extraction.	*2*	*75*	*60*	*H*	*H*	*H*	*-*	*H*	*H*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	Get awareness of safety techniques and handling of chemicals.	*2*	*80*	*70*	*H*	*H*	*-*	*H*	*-*	*-*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-3 :	Understand how to carry out different types of reactions and their workup methods.	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*-*	*-*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-4 :	Understand the Principles of mass spectroscopy, gas chromatography and HPLC	*2*	*70*	*70*	*H*	*-*	*H*	*H*	*H*	*-*	*M*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-5 :	Apply the techniques for structure determination of organic molecules.	*2*	*80*	*70*	*-*	*H*	*-*	*M*	*-*	*H*	*H*	*-*	*-*	*H*	*H*	*-*	*H*	*H*	*H*
CLO-6 :	Acquire insight about the setting up a reaction	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		18	18	18	18	18
S-1 to 6	SLO-1	**Introduction** Spectroscopic Techniques: Compounds to be synthesized by one step reaction have to be characterized by modern spectroscopic techniques (UV-Vis, FT-IR, NMR).	3. 4-Nitrobenzoic acid to 4-nitrobenzanilide (Substitution)	6. Cyclohexanone → Phenyl hydrazone → 1,2,3,4-Tetrahydrocarbazole	3. Mixture 3	6. Mixture 6
	SLO-2					
S-7 to 12	SLO-1	1. 2,4,6-trinitrophenol(picric acid)from phenol (nitration)	*4. o*-Chlorobenzoic acid from anthranillic acid (Sandmeyer reaction)	Analysis of an organic mixture containing two components: 1. Mixture 1	4. Mixture 4	Repeat Class -1
	SLO-2					
S-13 to 18	SLO-1	2. Benzophenoneoxime from benzophenone (addition reaction)	5. 4-Nitro toluene → 4-Nitro benzoic acid → 4-Amino benzoic acid	2. Mixture 2	5. Mixture 5	Repeat Class -2
	SLO-2					

Learning Resources	References 1. Vogel, A Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall, 1996. 2. Fieser and Fieser, Reagents in Organic Synthesis, Wiley, 2006. 3. Mann &Saunders, Practical Organic Chemistry, 4thEd., Longmans, 1960. 4. H. T. Clarke., A Handbook of Quantitative & Qualitative Analysis, Arnold Heinemann, 1975.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	30%	-	30%	-	30%	-	30%	-	30%
	Understand										
Level 2	Apply	-	40%	-	50%	-	50%	-	50%	-	50%
	Analyze										
Level 3	Evaluate	-	30%	-	20%	-	20%	-	20%	-	20%
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. Baskar Baburaj, SRMIST
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Course Code	PCD21AE2T	Course Name	General Aptitude for Competitive Examinations	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	Recapitulate fundamental mathematical concepts and skills
CLR-2:	Provide context - based vocabulary enhancement
CLR-3:	Sharpen logical reasoning through skilful conceptualization
CLR-4:	Familiarize with basic grammatical and syntactical rules
CLR-5:	Enable to solve problems and to crack competitive exams
CLR-6:	Develop new strategies to enhance reading comprehension

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1:	*Build a strong base in the fundamental mathematical concepts*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Acquire strategies to build vocabulary*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*Apply the learn conditions towards solving problems analytically*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*Learn grammatical and syntactical rules*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Grasp the approaches and strategies to solve problems with speed and accuracy*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Improve reading comprehension strategies*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		3	3	3	3	3
S-1	SLO-1	Logical Reasoning I	Vocabulary from inference to meaning	Numbers - I	Error Identification - I	Data Sufficiency
	SLO-2	Solving Problems	Vocabulary from inference to meaning	Numbers - I	Error Identification - I	Data sufficiency
S-2	SLO-1	Logical Reasoning - I	Cloze passage	Numbers - II	Error Identification - II	Data Interpretation
	SLO-2	Solving Problems	Cloze passage	Numbers - II	Error Identification - II	Data Interpretation
S-3	SLO-1	Logical Reasoning - I	Sentence Completion	Numbers - III	Sentence Correction - I	Sentence Correction - II
	SLO-2	Solving problems	Sentence Completion	Numbers - III	Sentence Correction - I	Sentence Correction - II

Learning Resources	1. Quantitative aptitude - r s agarwal 2. Quantitative aptitude - ARUN SARMA 3. ManhattanPrepGMAT Sentence Correction Guide-Avi Gutman	4. GRE Contextual.Vocabulary-Ken Springer

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA - 1 (10%)		CLA - 2 (10%)		CLA - 3 (20%)		CLA - 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
Experts from Industry	Internal Experts	
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2.Mr Ajay Zenner, Career Launcher, **ajay.z@careerlauncher.com**	2. Dr.M.Snehalatha SRMIST	4. Dr. J Jayapragash, SRMIST

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Semester-III

Course Code	PCY21301T	Course Name	*Organometallic and Bioinorganic Chemistry*	Course Category	*C*	*Professional Core Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-1 :	*Gain knowledge of the basic concepts of organometallic chemistry*																		
CLR-2 :	*Address concepts related to organometallic chemistry using stability based on 18-electron rule*																		
CLR-3 :	*Employ various organic reactions towards the design of fine chemical and drug molecules for industries*																		
CLR-4 :	*Get knowledge on organometallic compounds as various types of catalyst*																		
CLR-5 :	*Utilize the bioinorganic chemistry in various pharmaceutical problems and identify appropriate solutions*																		
CLR-6 :	*Address the concepts related to the active sites and action cycles of the metalloenzymes*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Apply 18-electron rule to rationalize the stability of organometallic compounds*	*2*	*75*	*60*	*H*	*H*	*H*	*M*	*H*	*H*	*L*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*
CLO-2 :	*Employ concepts of organometallic chemistry in fine chemical for industry*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*L*	*L*
CLO-3 :	*Develop a general idea of catalysis and describe the mechanism in detail*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*L*	*L*
CLO-4 :	*Solve periodically by incorporation of organometallic compounds into organic synthesis problems*	*2*	*70*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*M*	*H*	*L*	*L*
CLO-5 :	*Explain the sources and consequences of excess and deficiency of trace metals and learn about the toxicity of certain metal ions*	*2*	*80*	*70*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*
CLO-6 :	*Utilize concepts in bioinorganic chemistry for scientific advancement towards the developments of various drugs*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	**SLO-1**	Type of ligands and eighteen electron rule	Synthesis, structure, bonding of transitional metal complexes with alkenes	Homogeneous catalysis	Photosystems	Oxygen binding properties of heme
	SLO-2	Transition metal carbonyl complexes, substitutes for carbonyl ligands	reactivity of transitional metal complexes with alkenes	Hydrogenation	porphyrins	haemoglobin
S-2	**SLO-1**	Non-carbon ancillary ligands	Cyclopentadienyl	Hydroformylation	Ion (Na^+ and K^+) transport	myoglobin
	SLO-2	Ligand	Cycloheptatriene	Acetic acid synthesis	oxygen binding	their coordination

Duration (hour)		12	12	12	12	12
		substitution reactions, ligand insertion reactions				geometry,
S-3	SLO-1	Synthesis of Carbene complexes	Cyclooctatetraene	Heterogeneous catalysis	Transport and utilization	electronic structure
	SLO-2	Reactivity of Carbene complexes	benzenoid	Fischer-Tropsch reaction	Electron transfer reactions	co-operativity effect
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-5	SLO-1	Transition metal organometallics: square planar complexes	n-allyl, and enyl systems,	Ziegler-Natta polymerization	nitrogen fixation	Non-heme proteins (hemocyanin & hemerythrin)
	SLO-2	metal alkyls	metathesis reactions	Olefin oxidation	nitrogen fixation	their coordination geometry
S-6	SLO-1	Synthesis of Metal alkylidenes	Migratory insertion reaction with alkynes	isomerisation	Metalloenzymes	electronic structure
	SLO-2	Reactivity of Metal alkylidenes	C - C single bond formation reactions	Addition of HX to olefins	Metalloenzymes containing different metals	Electron transfer proteins
S-7	SLO-1	Synthesis of Metal alkylidynes	Oxidative addition, transmetallation	carbonyl insertion	magnesium	Active site structure and functions of ferredoxin and rubridoxin
	SLO-2	Reactivity of Metal alkylidynes	Reductive elimination, insertion, and (β-hydride and alkyl) elimination reactions	Hydride elimination	Molybdenum	Cytochromes and their comparisons
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-9	SLO-1	Synthesis of Metal arenes	Reactions involving organocopper and palladium intermediates and other transition metals	abstraction	Iron	Characterization techniques:
	SLO-2	Reactivity of Metal arenes	Suzuki reactions	Cyclooligomerisation	Cobalt	UV-Vis, Raman spectroscopy
S-10	SLO-1	Vaskas complex	Stille reactions	ethylene dimerization using $RhCl_3$ as catalyst	Copper	X-Ray crystallography
	SLO-2	Isolobal analogy	Negishi coupling reactions	Asymmetric catalysis	Zinc	Paramagnetic NMR, EPR spectroscopy
S-11	SLO-1	Fluxional properties of organometallics	Ullman coupling reactions	Organometallic compounds in medicine, agriculture.	Role of metal complexes in medicine	EXAFS
	SLO-2	Fluxional properties of organometallics	Heck reaction with mechanism	Horticulture, and other industries	Role of metal complexes in medicine	Magnetic susceptibility and electrochemistry
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial

Learning Resources	1. G. O. Spessard and G. L. Miessler, Organometallic Chemistry, Prentice Hall, Upper Saddle River, NJ, 1997. 2. C. Elschenbroich, Organometallics: A Concise Introduction Wiley-VCH: Weinheim, 2006. 3. D. Steinborn, Fundamentals of Organometallic Catalysis Wiley-VCH, 2012. 4. I. Bertini, H. B. Gray, S. J. Lippard, and J.S. Valentine, Bioinorganic chemistry, University Science Books, 1994. 5. E.I.Stiefel, and G. N. George, Ferredoxins, hydrogenases, and nitrogenases: Metal-sulfide proteins. Bioinorganic Chemistry, 1994.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	*Dr. G. T. Senthilandavan, SRMIST*

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Course Code	PCY21302T	Course Name	Quantum Chemistry and Molecular Spectroscopy	Course Category	C	Professional Core Course	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

CLR-1 :	*Emphasize the need of quantum mechanics*
CLR-2 :	*apply the required mathematics for solving quantum mechanical problems*
CLR-3 :	*Apply the quantum mechanics in solving for the shapes of orbitals*
CLR-4 :	Address the quantization of energy and the interaction of electromagnetic radiation with matter
CLR-5 :	*Learn the molecular spectroscopy fundamentals and selection rules of spectroscopy*
CLR-6 :	*Explore the Rotational, Vibrational, Raman and Electronic spectra molecules*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	*Describes about various theories of hypothesis of matter waves*	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Evaluates the quantum mechanical operator, eigen value of wave functions*	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	*Understand the physical and mathematical aspects of quantum chemistry and atomicstructure.*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	*Identifies the basics elements of spectroscopy*	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	*Discuss the selections rule of various spectroscopy*	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6 :	*Examine the rotational and vibrational, Raman, electronic and spin resonance spectra of molecules.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	SLO-1	de-Broglie 's concept of matter waves	Particle in a one-dimensional box - Schrodinger wave equation Derivation	Schrodinger wave equation for Rigid Rotator-Derivation	Time-dependent states and spectroscopy: Absorption and emission of radiation	Electronic spectroscopy: diatomic molecules
	SLO-2	experimental verification of matter waves	Particle in a one-dimensional box - Schrodinger wave equation Derivation	Schrodinger wave equation for Rigid Rotator-Derivation	Time-dependent states and spectroscopy: Absorption and emission of radiation	Electronic spectroscopy: diatomic molecules
S-2	SLO-1	Compton effect	quantization of energy	Solving ofSchrodinger wave equation for Rigid Rotator	selection rules, line shapes and widths	Franck-Condon factor
	SLO-2	Heisenberg 's uncertainty principle	normalization of wave function	Solving of Schrodinger wave equation for Rigid Rotator	Fourier transform spectroscopy	dissociation and pre-dissociation
S-3	SLO-1	Derivation of Schrodinger wave equation	Orthogonality of the particle in a one-dimensional box wave function	Energy of rigid rotator	Rotation and vibration of diatomic molecules: rotational spectra of rigid rotor - wave functions	rotational fine structure
	SLO-2	Derivation of Schrodinger wave equation	Orthogonality of the particle in a one-dimensional box wave	space quantization	- Its energies	rotational fine structure

Duration (hour)		12	12	12	12	12
			function			
S-4	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-5	SLO-1	Requirements for acceptable wave functions	average position of a particle in a one-dimensional box	Schrodinger wave equation for hydrogen atom-Derivation	Rotation and vibration of diatomic molecules: vibrational spectra of harmonic oscillator - wave function	Lasers and laser spectroscopy
	SLO-2	Requirements for acceptable wave functions	average momentum of a particle in a one-dimensional box	Schrodinger wave equation for hydrogen atom-Derivation	-its energies	XPS-PES
S-6	SLO-1	Operators, linear operators	Illustration of the uncertainty principle	Separation of variable in polar spherical coordinates	Selection rules, a review of microwave spectroscopy	Spin resonance spectroscopy: spin and an applied field
	SLO-2	estimating the following quantum mechanical operators: position,	Correspondence principle with reference to the particle in a one-dimensional box.	Schrodinger wave equation for hydrogen atom- solution	Selection rules, a review of IR spectroscopy	the nature of spinning particles
S-7	SLO-1	momentum, kinetic energy	Schrodinger wave equation for a particle in a three-dimensional box-derivation	Probability distribution function	Diatomic molecule wave functions	interaction between spin and magnetic field
	SLO-2	potential energy, total energy, angular momentum	Schrodinger wave equation for a particle in a three-dimensional box-derivation	radial distribution function	Diatomic molecule wave functions	interaction between spin and magnetic field
S-8	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
S-9	SLO-1	Hermiticity	the concept of degeneracy of energy levels	shape of atomic orbitals (s, p & d)	Symmetry properties and nuclear spin effects.	Larmor precession and population of energy levels.
	SLO-2	proving the quantum mechanical operators are Hermitian operators	the concept of degeneracy of energy levels	shape of atomic orbitals (s, p & d)	Vibrational - rotational spectrum of diatomic molecule	Nuclear magnetic resonance spectroscopy:hydrogen nuclei
S-10	SLO-1	Commutator algebra	Schrodinger wave equation for linear harmonic oscillator -Derivation	Eigen function of Hamiltonian representing Hydrogen atom	Raman effect: rotational and vibrational transitions,	chemical shift
	SLO-2	Evaluation of commutators	Schrodinger wave equation for linear harmonic oscillator - Derivation	Eigen values of Hamiltonian representing Hydrogen atom	Polarization of Raman lines	Coupling constant
S-11	SLO-1	Eigenfunctions, eigen values	solution by polynomial method	Orthogonality of wave functions of hydrogen atom	Vibration of polyatomic molecules, normal coordinates	coupling between several nuclei
	SLO-2	Postulates of quantum mechanics	zero-point energy, its consequences	Orthogonality of wave functions of hydrogen atom	Rule of mutual exclusion	coupling between several nuclei
S-12	SLO-1	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session
	SLO-2	Tutorial session	Tutorial session	Tutorial session	Tutorial session	Tutorial session

Learning Resources	1. R.K.Prasad, Quantum Chemistry, 4th edition, New Age International, (P)Ltd.,Publishers, 2010. 2. D.A.McQuarrie,*QuantumChemistry*,2nd Ed.,UniversityScienceBooks,California,2008. 3. A.K. Chandra, *Introductory Quantum Chemistry*, 4th edition, Tata McGraw Hill education,1994. 4. Ira. Levine, *Quantum Chemistry*, 7thEd.,Prentice Hall, 2013. 5. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*,4thEd., Tata McGraw Hill, New Delhi,2008. 6. Gurudeep Raj, Advanced Physical chemistry, 32nd edition, Goel Publishing house, Krishna Prakashan Media (P) Ltd, 2006.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. Bhalchandra Kakkade, SRMIST

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Course Code	PCY21303T	Course Name	*Analytical Chemistry*	Course Category	*C*	*Professional Core Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the fundamental principles of analytical chemistry and data analysis .*																		
CLR-2 :	*Be aware about modern analytical techniques and their applications.*																		
CLR-3 :	*Learning basics of separation techniques and its applications and Understanding analytical tools, statistical methods in analytical chemistry.*																		
CLR-4 :	*Understanding principles of thermo-gravimetric analysis and study of thermal decomposition of materials/characterization of materials.*																		
CLR-5 :	*Understanding basics of electro-analytical techniques and their applications.*																		
CLR-6 :	*Understanding principles of various chromatography with advanced Instrumentations and applications.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	*Develop methods of analysis for different samples independently.*	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Perform experiment with accuracy and precision.*	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	*Develop skills for separation of analytes by chromatography.*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	Perform Thermo-gravimetric Analysis of different compounds	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	Posses' analytical experience on interpretation of GC/HPLC data of known compounds.	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6 :	*Gain knowledge about the electroanalytical techniques and its implementation in various applications.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	**SLO-1**	*Data analysis and good lab practice.* Principle of GLP and handling of first aid.	*Classical analytical methods.* Principle of volumetric analysis.	*Analytical separation and purification techniques.* Precipitation - definition with examples.	*Electrochemical analysis.* Specific Conductance and Molar conductance.	*Thermal analysis.* Introduction
	SLO-2	Safety, storage and handling of chemicals.	Concept of solubility product.	Separation techniques and types.	Kohlrausch's law and its applications.	Description of Thermoanalytical methods
S-2	**SLO-1**	Definition for Antidotes with examples, threshold vapour concentration and	Common ion effect and its applications in qualitative and volumetric analyses.	Distillation- definition with examples	Measurement of dissociation constant.	Principle of TGA,

Duration (hour)		12	12	12	12	12
		its safety limits.				
	SLO-2	Accuracy and precision definitions	Principles of gravimetric analysis	Types of distillation - steam, fractional and vacuum.	coulometric titrations.	Instrumentation and applications.
S-3	SLO-1	Definition and importance of Sensitivity and specificity.	Gravimetric methods and its applications.	Solvent extraction principles.	conductometric titrations	Principle of DTA -,
	SLO-2	Definition and problems based on Standard deviation and mean.	Theories of Precipitation.	Chromatography - principle and its types.	Introduction to electrochemical cells.	Instrumentation and applications.
S-4	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-5	SLO-1	Errors	Precipitation from homogenous medium.	Partition chromatography	Types of Electrochemical Cells - Galvanic cells and Electrolytic cells.	Characteristics of TGA curves
	SLO-2	Classification of errors- systematic (determinate), random (indeterminate).	Co-precipitation reactions.	Column chromatography and its Applications.	Standard electrode potential, and electrochemical series.	DTA, thermograms.
S-6	SLO-1	Minimization of errors.	Post precipitation reactions with examples.	Thinlayer chromatography (TLC) and its Applications.	Nernst equation.	Factors affecting TGA curves
	SLO-2	Definition - significant figures.	Titrations, Theories of acid-base titration.	Paper chromatography and its Applications.	Potentiometry - basic principles.	Thermograms of calcium oxalate monohydrate.
S-7	SLO-1	Problems based on significant figures.	Redox and complexometric titrations.	Ion exchange chromatography: principle.	Ion-selective electrodes	Factors affecting DTA curves
	SLO-2	Rejection of data and its criteria.	Iodimetric titrations.	Instrumentation and applications.	Liquid membrane electrodes - applications.	DTA curves of calcium oxalate monohydrate and others.
S-8	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
S-9	SLO-1	Q test,	Buffer solutions with examples.	Suppressor columns	Voltammetry principles and applications.	Advantages of TGA
	SLO-2	T test	Indicators - theories of indicators.	Principles, instrumentation and applications of GC.	Voltammograms, equation of voltammogram and modified voltametric methods.	Advantages of DTA.
S-10	SLO-1	F test	acid-base indicators and redox-metal ion.	HPLC - Principles,	Cyclic voltammetry, amperometry and anodic stripping voltammetry.	Thermometric titration
	SLO-2	Definitions - control chart,sampling methods.	Adsorption indicators and metal ion indicators.	Instrumentation and applications.	Polarography basic principles and applications.	Principle and applications.
S-11	SLO-1	Sampling error and statistical data treatment.	choice of indicators	Signal to noise ratio.	Electrochemical Sensors, modified electrodes and their applications,	Electrogravimetry
	SLO-2	Standard reference materials.	Limitations of volumetric analysis.	Sources of noise in instrumental analysis.	Principle, instrumentation, operation and applications of electronic tongue.	Principle and applications.

Duration (hour)		12	12	12	12	12
S-12	SLO-1	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial
	SLO-2	Tutorial	Tutorial	Tutorial	Tutorial	Tutorial

Learning Resources	
	1. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of AnalyticalChemistry*, 9th Ed., Brooks Cole, 2013. 2. G. D. Christian, *Analytical Chemistry*, 6th Ed., Wiley, 2007. 3. D. A. Skoog, F. J. Holler and S. R. Crouch, *Principles of Instrumental Analysis*, Thomson Learning, 2007. 4. H. H. Willard, L. Jr. Merritt., J. A. Dean and F. A. Settle, *Instrumental Methods of Analysis*,7th Ed., CBS Publishers, 2007. 5. R.M. Verma, *Analytical Chemistry Theory and Practice*, 3rd Ed., CBS Publishers, 1994. 6. B. K. Sharma, *Instrumental Methods of Analysis*, 28th Ed., GOEL Publishing House, 2012. 7. N. Gray, M. Calvin and S.C. Bhatia, *Instrumental Methods of Analysis*, CBS Publishers, 2009.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	*Dr. Ashok Kumar Sundramoorthy, SRMIST*
	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	*Dr.Srinivasa Rao, SRMIST*

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Course Code	POC21301T	Course Name	*Modern Synthetic Reagents and Photochemistry*	Course Category	*C*	*Professional Core Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Enable them to learn about different types of Organic reagents and methods used in modern organic synthesis.*																		
CLR-2 :	*Develop the skills in designing synthetic strategies for various targets.*																		
CLR-3 :	*Explore the use of several important reagents and their implication in the modern organic transformations.*																		
CLR-4 :	*Get a significant exposure in research and development for future development.*																		
CLR-5 :	*Develop capabilities as an organic chemist in pharmaceutical industries.*																		
CLR-6 :	*Strengthen knowledge in the area of organic synthesis.*																		

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	*Understand the basic principles of photochemistry.*	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	-	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquaint students with the use of protecting groups in organic synthesis.*	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	*Gain knowledge about various important reagents and methods in organic Synthesis.*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	*Understand the principles of asymmetric synthesis.*	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge about the in multistep organic synthesis.*	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6 :	*Acquaint students with the understanding of designing easily achievable cost effective synthetic route.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	**SLO-1**	Functional group transformations using various oxidizing reagents (PCC, PDC, PFC)	Role of Palladium catalyst in organic reactions	Introduction to Protecting group in organic synthesis	Absorption of light by organic molecules, Jablonski diagram	Principles of asymmetric synthesis
	SLO-2	Functional group transformations using oxidizing reagents (CTAP, RuO_4, $KBrO_3$)	Role of Nickel catalyst in organic reactions	Qualities of a Good Protecting Group in Organic Synthesis	Properties of excited states, mechanism of excited state processes	Introduction, the chiral pool in Nature
S-2	**SLO-1**	Functional group transformations using Reducing reagents ($NaCNBH_3$, Bu_3SnH)	Heck, Negishi reaction	Qualities of a Good Protecting Group in Organic Synthesis	Methods of preparative photochemistry	Methods of asymmetric induction
	SLO-2	Functional group transformations using Reducing reagents (Et_3SiH and Hydrazine)	Suzuki- Miyaura, Kumada,	Protecting groups for N.	Photochemistry of alkenes and related compounds: isomerization	Substrate controlled reactions

Duration (hour)		12	12	12	12	12
S-3	SLO-1	Functional group transformations using miscellaneous reagents ($SOCl_2$, PBr_3, PPh_3-CCl_4)	Sonogashira, Stille and Hiyama coupling	Protecting groups for O	Di-π-methane rearrangement and cycloadditions	Reagent and catalyst controlled reactions
	SLO-2	Functional group transformations using the reagents LiBr, NaI, NBS, PPh_3-X_2	Buchwald-Hartwig coupling for the carbon-heteroatom bond formation reaction.	Protecting groups for Sulphur like alcohol	Photochemistry of aromatic compounds: ring isomerization	Synthesis of L-DOPA [Knowles's Mosanto process]
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session
S-5	SLO-1	Lawesson's reagent, Mitsunobu reagent	Organocatlysis: Lewis base catalysis, iminium catalysis, enamine catalysis,	Use of TMSI, TBAF	Photochemistry of aromatic compounds: cyclization reactions	Asymmetric reactions with mechanism: Aldol and related reactions
	SLO-2	Use of CH_2N_2, $TMSCHN_2$,	Lewis acid catalysis, Brønsted acid and base catalysis. Carbenes as organocatalysts,	Use of TBDMS, BnBr	Norrish type-I cleavage of acyclic, cyclic, and unsaturated carbonyl compounds	Cram's rule
S-6	SLO-1	Barbier-Weiland degradation	Different NHCs and their synthesis,	Use of DHP, CbzCl	Continued	Felkin-Anh model
	SLO-2	Conversion of aldehyde to ketone and vice versa	NHC catalyzed umpolung,	Use of Boc. anhydride, Fmoc-Cl, acetals as protecting groups for diols.	Norrish type-II cleavage	Sharpless enantioselective epoxidation
S-7	SLO-1	Conversion of aldehyde to cyanide	NHC catalyzed transesterification reactions	Protection of carbonyl groups in aldehydes and ketones	Hydrogen abstraction: intramolecular and intermolecular hydrogen abstraction	Sharpless enantioselective hydroxylation
	SLO-2	Conversion of cyanide to ester	Homo and cross benzoin type reactions, Stetter reaction	Protection of carbonyl groups in aldehydes and ketones	Photoenolization	Amino-hydroxylation
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session
S-9	SLO-1	Conversion of ketone/aldehyde to phenol	Enolate chemistry, homo enolate derived reactions	Protection of the carboxyl group	Photocyclo-addition of ketones with unsaturated compounds	Diels-Alder reaction
	SLO-2	Conversion of ketone to enone	Addition to ketenes and analogues,	Protection of double and triple bonds.	Paterno-Buchi reaction, Barton reaction	Reduction of prochiral carbonyl compounds and olefins
S-10	SLO-1	Synthetic utility of Samarium iodide in organic synthesis	Oxidative NHC catalysis,	Protection of double and triple bonds	Photodimerisation of α, β unsaturated ketones	Use of chiral auxiliaries in diastereoselective reductions
	SLO-2	Synthetic utility of Samarium Ruthenium in organic synthesis (Ring closure reaction)	Cooperative catalysis with metal catalysts	Applications of the protection and deprotection of the hydroxyl group in organic synthesis.	Rearrangement of enones and dienones	Asymmetric, amplification
S-11	SLO-1	Continued (Metathesis-RCM)	Cooperative catalysis with metal catalysts	Applications of the protection and deprotection of the	Rearrangement of enones and dienones	Use of chiral BINOLs, BINAPs and chiral

Duration (hour)		12	12	12	12	12
				carbonyl functional group in organic synthesis.		oxazolines
	SLO-2	Synthetic utility of Samarium Cobalt in organic synthesis (Pauson-Khand reaction and Nicholas reaction).	Cooperative catalysis with other organo catalysts	Applications of the protection and deprotection of the amino and carboxyl functional groups in organic synthesis.	Photo-Fries rearrangement	Asymmetric transformations
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session

Learning Resources	
	1. J. Clayden, N.Greeves, S. Warren and P. Wothers, Organic Chemistry, 1st Ed., Oxford University Press, 2001.
	2. M.B. Smith & J.March, March's Advanced Organic Chemistry, 5th Ed., John Wiley & Sons, New York, 2001.
	3. F.A. Carey and R.A. Sundberg, Advanced Organic Chemistry, Part A and Part B, 5th Ed., Kluwer Academic/Plenum Publishers, New York, 2004
	4. P. G. M. Wuts, Greene's Protective Groups in Organic Synthesis, 5th Ed., Wiley, 2014.
	5. 5. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Ed., Orient Longman Ltd., New Delhi, 1997.
	6. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rdEd., Addison-Wesley.
	7. Modern Methods of Organic Synthesis, Fourth edition by William Carruthers and Iain Coldham.

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	PCY21D05T	Course Name	*Supramolecular Chemistry and Crystal Engineering*	Course Category	*D*	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Enable them to learn the underlying principles of supramolecular chemistry*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	*Strengthen the knowledge of the students in supramolecular chemistry*																		
CLR-3 :	*Explore noncovalent interactions to form supramolecular assembly.*																		
CLR-4 :	*Get a significant exposure in emerging field crystal engineering*																		
CLR-5 :	*Express their capabilities to find applications in molecular devices including smart actuators and molecular switches*																		
CLR-6 :	*Strengthen the skill in the area of supramolecular chemistry to achieve suitable applications.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the basic principles of supramolecular chemistry*	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquaint students with the fundamental concepts of Molecular recognitions in supramolecular chemistry*	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	*Gain knowledge about various noncovalent interactions to form supramolecular assemblies*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	*Understand the concept of crystal engineering*	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge about the Host-guest chemistry*	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6 :	*Acquaint students with the understanding of designing tailored molecules and crystals for appropriate applications.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		12	12	12	12	12
S-1	**SLO-1**	Terminology and nomenclature in supramolecular chemistry	Basic understanding of Host-guest chemistry	Basic understanding of crystal engineering	Self-assembly of molecules: Design, synthesis and properties of the molecules	Molecular electronic devices
	SLO-2	continued	Synthesis and structure of crown ethers	Basic understanding of crystal engineering	Self-assembly of molecules: Design, synthesis and properties of the molecules	Molecular electronic devices
S-2	**SLO-1**	Definition of supramolecular chemistry	Synthesis and structure of crown ethers	Role of H-bonding, halogen bonding and other weak interactions	Self-assembly of molecules: Design, synthesis and properties of the molecules	Molecular wires and rectifiers
	SLO-2	Various examples of supramolecular assemblies	lariat ethers, podands, cryptands	Role of H-bonding, halogen bonding and other weak interactions	Self-assembling by H-bonding, metal-ligand interactions and other weak interactions	Molecular wires and rectifiers
S-3	**SLO-1**	Chemical interactions	lariat ethers, podands, cryptands	Co-crystals, salts, polymorphs and their	Self-assembling by H-bonding, metal-ligand	Molecular switches and logic

Duration (hour)		12	12	12	12	12
		leading to supramolecular assemblies		physico-chemical properties	interactions and other weak interactions	gates
	SLO-2	Continued	Spherands, calixarenes,	Co-crystals, salts, polymorphs and their physico-chemical properties	Self-assembling by H-bonding, metal-ligand interactions and other weak interactions	Molecular switches and logic gates
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session
S-5	SLO-1	Nature of binding interactions in supramolecular structures	Cyclodextrins, cyclophanes,	Design of molecular crystals towards achieving targeted applications	metallomacrocycles	Relevance of supramolecular chemistry to mimic biological systems
	SLO-2	Ion-ion, ion-dipole interactions	cryptophanes	Design of molecular crystals towards achieving targeted applications	catenanes	Relevance of supramolecular chemistry to mimic biological systems
S-6	SLO-1	Continued	carcerands, and hemicarcerands	Mechanical properties of molecular crystals	catenanes	cyclodextrins as enzyme mimics
	SLO-2	Dipole-dipole, H-bonding	carcerands, and hemicarcerands	Mechanical properties of molecular crystals	rotaxanes	cyclodextrins as enzyme mimics
S-7	SLO-1	cation-pi, anion-pi interactions	Host-guest interactions, pre-organization and complementarity	Coordination polymers	rotaxanes	ion channel mimics
	SLO-2	cation-pi, anion-pi interactions	Host-guest interactions, pre-organization and complementarity	Coordination polymers	rotaxanes	ion channel mimics
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session
S-9	SLO-1	pi-pi and Van der Waals interactions	Lock and key analogy	Metal organic frameworks	helicates and knots	supramolecular catalysis
	SLO-2	pi-pi and Van der Waals interactions	Lock and key analogy	Metal organic frameworks	helicates and knots	supramolecular catalysis
S-10	SLO-1	Various examples to illustrate noncovalent interactions	Binding of cationic, anionic, ion pair and neutral guest molecules.	Binary and Ternary cocrystals	Examples of recent developments in supramolecular chemistry.	supramolecular catalysis
	SLO-2	Various examples to illustrate noncovalent interactions	Binding of cationic, anionic, ion pair and neutral guest molecules.	Binary and Ternary cocrystals	Examples of recent developments in supramolecular chemistry.	supramolecular catalysis
S-11	SLO-1	Supramolecular assemblies for various applications	Various examples to illustrate noncovalent interactions	Various applications of crystal engineering	Examples of recent developments in supramolecular chemistry.	Question answer Session
	SLO-2	Supramolecular assemblies for various applications	Various examples to illustrate noncovalent interactions	Various applications of crystal engineering	Examples of recent developments in supramolecular chemistry.	Question answer Session
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Question answer Session	Question answer Session	Question answer Session	Question answer Session	Question answer Session

Learning Resources	*1. J.M. Lehn, Supramolecular Chemistry-Concepts and Perspectives, Wiley-VCH, 1995.* *2. P. D. Beer, P. A. Gale and D. K. Smith, Supramolecular Chemistry, Oxford University Press, 1999.* *3. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, 1st Ed., Wiley, 2000.* *4. J. W. Steed, Core Concepts in Supramolecular Chemistry and Nanochemistry,1stEd., John Wiley & Sons, 2007.* *5. J.D. Seader, I. W. Hamley, Introduction to soft mater Synthetic and Biological self-assembly materials, Separation process principles,2nd Ed., Wiley, 2010.* *6. G. R. Desiraju, J. J. Vittal and A. Ramanan, Crystal Engineering: A Textbook, World Scientific, 2011.*

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. Soumyajit Ghosh, SRMIST
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Course Code	PCY21D06T	Course Name	*Advanced Electrochemistry*	Course Category	*D*	*Discipline Elective Course*	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3
CLR-1 :	*Understand the theories and concepts of electrochemistry.*			
CLR-2 :	*learn about the electrodes and electrodics*			
CLR-3 :	*Understand the principle and working of polarography*			
CLR-4 :	*Gain knowledge about the modern areas of electrochemistry like electrocatalysis, photoelectrocatalysis*			
CLR-5 :	*Expand the new horizon of electrochemistry in the field of bioelectrodics*			
CLR-6 :	*Gain the knowledge about the different types of sensors*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	*Explain fundamental aspects of electrochemical reaction*	2	75	60	H	H	H	L	H	H	M	H	H	M	L	H	H	H	H
CLO-2 :	*Explain the structure of electric double layer at the interface and its role on electrode reactions.*	2	80	70	H	H	L	H	L	M	H	M	M	H	M	L	H	H	H
CLO-3 :	*Explain measuring principle of fundamental electrochemical methods such as polarography*	2	70	65	H	H	H	M	M	H	H	H	H	H	M	M	H	H	H
CLO-4 :	*Apply the Nernst, Butler-Volmer and Tafel equations to electrochemical systems*	2	70	70	H	H	H	H	H	M	M	H	L	H	M	M	H	H	H
CLO-5 :	*Describe and apply new horizons of electrochemistry in terms of bioelectrodics*	2	80	70	M	H	H	M	M	H	H	M	H	H	H	L	H	H	H
CLO-6 :	*Describe and apply the usage of enzymes as electrodes*	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Ions in solution: deviation from ideal behaviour	Basics of electrodics	electro-chemical reaction mechanisms	Standard electrodes	Photoelectrochemistry - introduction
	SLO-2	ionic activity	Rates of simple electrode reactions	electrochemical reaction order	electrodes at equilibrium	band bending at the semiconductor/solution interface
S-2	SLO-1	ion-solvent interaction	Butler-Volmer equation	Types of over voltages	Ohmic behaviors	photoexcitation of electrons by absorption of light,
	SLO-2	ion-ion interaction	Butler-Volmer equation - Continued	Types of over voltages	non-Ohmic behavior	photoexcitation of electrons by absorption of light - continued
S-3	SLO-1	expression for the free energy	exchange current density and symmetry factor	chemical and electrochemical over potentials	reactions at an electrode	surface effects in photoelectrochemistr
	SLO-2	expression for the free energy	electrode rectification	Phase overpotential	reactions at an electrode	photoelectrocatalysis

Duration (hour)		12	12	12	12	12
S-4	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-5	SLO-1	Debye-Huckel-Bjerrum model	Nernst equation as a special case of the Butler -Volmer equation	Activation overpotential	three electrode system	the photoelectrochemical splitting of water
	SLO-2	mean activity coefficien	Nernst equation as a special case of the Butler -Volmer equation	concentration overpotential	sign conventions	the photoelectrochemical reduction of CO2
S-6	SLO-1	applications of Debye-Huckel limiting law	polarisable & non-polarisable electrode	diffusion, migration and hydrodynamic modes of transports	rates of electrochemical reactions	bioelectrodics
	SLO-2	extent of dissociation of a weak electrolyte in the presence of an inert electrolyte	low and high field approximations	diffusion, migration and hydrodynamic modes of transports	rates of electrochemical reactions - Continued	membrane potentials
S-7	SLO-1	Debye-Huckel theory of strong electrolytes	Tafel equations	the role of supporting electrolyte- General idea	chemical conditions for the discharge of ions	electrochemical communication in biological organisms
	SLO-2	Debye-Huckel theory of strong electrolytes	Tafel equations - Continued	the role of supporting electrolyte - explanation	electrochemical conditions for the discharge of ions	enzymes as electrodes
S-8	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
S-9	SLO-1	Debye-Huckel-Onsager treatment of the conductance of strong electrolyte and its limitations	Butler-Volmer equation for a multi step reaction	theory of diffusion over potential	Electrocatalyst	electron tra*n*sfer in p450 enzyme
	SLO-2	the electrical double layer,	Butler-Volmer equation for a multi step reaction	theory of diffusion over potential	electrogrowth of metals	electrochemical sensors,
S-10	SLO-1	Helmholtz-Perrin model of electrical double layer	the concept of rate determining step of an electrode reaction	Polarography - principle	hydrogen evolution reactions	electrochemical biosensors
	SLO-2	Guoy-Chapmann model of electrical double layer	transfer coefficients and stoichiometric number	Polarography - Working	electronation of oxyge	gas sensors
S-11	SLO-1	Stern model of electrical double layer	determining the stepwise mechanism of an electrodic reaction	limiting current density	corrosion and stability of metals	solid state devices
	SLO-2	Applications and limitations.	current potential laws for electrochemical systems	Polarography - applications	electrochemical energy conversion, electricity storage	sensor arrays
S-12	SLO-1	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session
	SLO-2	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session	Tutorial Session

Learning Resources	
	1. J.O.M. Bockris and A.K.N. Reddy, Modern Electrochemistry, Volumes 1 & 2, Plenum Press, New York. 1988 **2.** S.Glasstone, Electrochemistry, Affiliated East-West Press, Pvt., Ltd., New Delhi, 1974. **3.** A.J.Bard and L.R. Faulkner, Electrochemical methods -Fundamentals and Applications,,2nd Ed., John Wiley and Sons, 2001 **4.** C.Hamann, A. Hamnett and W. Vielstich, Electrochemistry, Wiley, 2007

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
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	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr.J.Arockia Selvi, *SRMIST*

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Course Code	PCY21S02L	Course Name	*Instrumental Methods of Analysis- Practical*	Course Category	*S*	*Skill Enhancement Course*	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3
CLR-1 :	Gain exposure to the practical knowledge of Instrumments and its handling.			
CLR-2 :	Gain insight about the principle, instrumentation and interpretation of simple compounds in UV spectroscopy			
CLR-3 :	Learn about the analysis of different organic functional groups			
CLR-4 :	Gain knowledge about the characterization of simple compounds using different techniques			
CLR-5 :	Know how to maintain the record of experiments conducted			
CLR-6 :	Learn strategies for the green synthesis of simple molecules			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	1 Disciplinary Knowledge	2 Critical Thinking	3 Problem Solving	4 Analytical Reasoning	5 Research Skills	6 Team Work	7 Scientific Reasoning	8 Reflective Thinking	9 Self-Directed Learning	10 Multicultural Competence	11 ICT Skills	12 Life Long Learning	13 PSO -1	14 PSO -2	15 PSO-3
CLO-1 :	Understand different characterization techniques in simple molecules	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	Get awareness of safety techniques and handling of chemicals.	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	Understand how to carry out green synthesis and its applications	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4 :	Understand the Principles of UV spectroscopy,	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5 :	Apply the techniques for structure determination of simple molecules.	*2*	*80*	*70*	*L*	*H*	*L*	*M*	*L*	*H*	*H*	*L*	*L*	*H*	*H*	*L -*	*H*	*H*	*H*
CLO-6 :	Acquire insight about the principle and handling of various instruments	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		18	18	18	18	18
S-1 to 6	SLO-1	Introduction	Validating Beer - Lamberts law by finding the absorbance of a dye in UV-visible spectrophotometer	Separation and Identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values	Determination of a concentration of an acid by pH metry	Demonstration Practical Session
	SLO-2					
S-7 to 12	SLO-1	IR Absorption Spectra (Study of Aldehydes and Ketones)	Determination of concentration of Mixture of acids by conductometric method	Chromatographic separation of the active ingredients of plants, flowers and juices by TLC	Determination of the isoelectric pH of a protein	Repeat Class -1
	SLO-2					
S-13 to 18	SLO-1	Determination of a Mixture of Cobalt and Nickel using UV-visible spectrophotometer.	Estimation of Chloride by Potentiometric Titration (Precipitation reaction)	Synthesis of zinc oxide nanoparticle by sol gel method	Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple	Repeat Class -2
	SLO-2					

Learning Resources	References 1. Vogel, A Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall, 1996. ***2. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7)*** ***3. Instrumental Methods of Analysis, 7thed, Willard, Merritt, Dean, Settle.*** ***4. Y.R. Sharma, Elementary Organic Spectroscopy: Principles and Chemical Applications, 5th edition, S. Chand and company Ltd., Ram Nagar, New Delhi, 2010.*** ***5. D.A. Skoog, D.M. West and F.J. Holler, Analytical Chemistry: An Introduction, 5th edition, Saunders college publishing, Philadelphia, 1990***

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	30%	-	30%	-	30%	-	30%	-	30%
	Understand										
Level 2	Apply	-	40%	-	50%	-	50%	-	50%	-	50%
	Analyze										
Level 3	Evaluate	-	30%	-	20%	-	20%	-	20%	-	20%
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. T.Pushpa Malini SRMIST
	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. J. Arockiaselvi, SRMIST

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Course Code	PPY21G01T	Course Name	Energy Storage and Devices	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)															
CLR-1:	Provides basic knowledge in the multidisciplinary field of energy storage devices and their applications	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2:	Manage basic principles for accessible and relevant energy storage systems qualitatively.	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3:	*Learn concept and operation of available and relevant energy storage systems*																		
CLR-4:	*Identify different needs within energy storage.*																		
CLR-5:	*Cause of efficiency losses in various energy storage systems*																		
CLR-6:	*Identify available technologies and materials for energy storage and their application areas*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	*Understand the basic concepts of energy storage devices.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Gain the knowledge of electrochemical energy storage devices.*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*Realize the applications of magnetic and electric energy storage system*	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*Know about the fuel cell based energy storage system*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Understand the basic concepts of hydrogen production and storage*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Understand the concept and operation of available and relevant energy storage systems.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Definition and units of energy and power	Electrochemical energy storage-Battery	Magnetic and Electric energy storage system	Basics Fuel cell definition	Hydrogen production-From fossil fuels
	SLO-2	Definition and units of conservation of energy	Primary Batteries	Superconducting Magnetic Energy Storage (SMES)	Difference between batteries and fuel cells	Electrolysis
S-2	SLO-1	Definition of Second law of thermodynamics	Secondary Batteries	Capacitors and Batteries	Fuel cell history	Thermal decomposition
	SLO-2	Explanation of Second law of thermodynamics	Lithium Batteries	Comparison and application	Components of fuel cells	Thermal decomposition
S-3	SLO-1	PROBLEM Solving on Energy and Power	Simple numerical problem On Electrochemical energy storage	PROBLEM Solving on capacitors and batteries	Assignment to cover the history of fuel cell	Simple exercise on Electrolysis
	SLO-2	PROBLEM Solving on Second law of thermodynamics	Simple numerical problem On Electrochemical energy storage	PROBLEM Solving on capacitors and batteries	Assignment to cover the history of fuel cell	Simple exercise on Electrolysis
S-4	SLO-1	Energy resources	Solid state Batteries	Super capacitor	Principle of working of fuel cell	Photochemical

	SLO-2	Energy storage	Molten solvent Batteries	Super capacitor	Advantages and Disadvantages of fuel cell power plant	Photo catalytic
S-5	**SLO-1**	Need of energy storage	Lead Acid Batteries	Electrochemical double layer capacitor (EDLC)	Fuel cell types-Alkaline fuel cell	Hybrid storage
	SLO-2	Different modes of energy storage-Capacitors	Nickel cadmium Batteries	Principle of working of EDLC	Polymer electrolyte fuel cell	Hybrid storage
S-6	**SLO-1**	PROBLEM Solving on capacitors	Assignment on Solid state battery	Assignment on EDLC	Seminar related to various fuel power plants in India	Assignment on Hydrogen storage
	SLO-2	PROBLEM Solving on capacitors	Assignment on Solid state battery	Assignment on EDLC	Seminar related to various fuel power plants in India	Assignment on Hydrogen storage
S-7	**SLO-1**	Electrochemical energy storage	Advanced Batteries	Structure, Performance of EDLC	Phosphoric acid fuel cell	Metal hydrides
	SLO-2	Electrical energy storage	Advanced Batteries	Applications of EDLC	Molten carbonate fuel cell	Metallic alloy hydrides
S-8	**SLO-1**	Magnetic and , Chemical energy storage	Role of Carbon Nano-tubes in electrodes	Role of activated Carbon	Solid oxide fuel cell	Carbon Nano-tubes
	SLO-2	Hydrogen for energy storage	Role of Carbon Nano-tubes in electrodes	Role of Carbon Nano-tubes	Problems with fuel, Applications of fuel cells	Sea as the source of deuterium
S-9	**SLO-1**	Assignment on Electrochemical energy storage	Simple activity related to advanced batteries	Student seminar related to CNT	Assignment on Acid and Oxide fuel cell	Student seminar related to Deuterium
	SLO-2	Assignment on Electrochemical energy storage	Simple activity related to advanced batteries	Student seminar related to CNT	Assignment on Acid and Oxide fuel cell	Student seminar related to Deuterium

Learning Resources	1. R.A. Huggins, *Energy Storage*, 1st Ed., Springer, 2010. 2. J.-M. Tarascon, and Patrice Simon, *Electrochemical Energy Storage*, 1st Ed., Wiley, 2015. 3. F. Díaz-González, A. Sumper and O. Gomis-Bellmunt, *Energy storage in power systems*, 1st Ed., Wiley, 2016.	4. Srinivasan, *Fuel Cells from Fundamentals to Applications*, 1st Ed., Springer, 2006. 5. Basile, A. Iulianelli, *Advances in Hydrogen Production*, 1st Ed., *Storage and Distribution*, Woodhead Publishing, 2014. **6.** N. Kularatna, *Energy Storage Devices for Electronic Systems: Rechargeable Batteries and Supercapacitors*, Academic Press, 2014**.**

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA - 1 (10%)		CLA - 2 (10%)		CLA - 3 (20%)		CLA - 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. DK Aswal, National Physical Laboratory (NPL), *dkaswal@nplindia.org*	Prof. VS Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. Kamalabharathi

Course Code	PPY21G03T	Course Name	*LASER Physics*	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Physics and Nanotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning			Program Learning Outcomes (PLO)														
CLR-1:	*develop theoretical knowledge on lasers*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2:	*acquire the knowledge on laser beam characteristics*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-3:	*acquire knowledge for solving problems in laser physics*																		
CLR-4:	*analyze Fabry-Perot cavity to understand laser resonator*																		
CLR-5:	*acquire knowledge on Q-switched and mode-locked lasers*																		
CLR-6:	*acquire the knowledge on lasers classes and laser safety*																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1:	*understand the characteristics of a laser*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*understand the Fabry Perot resonator towards a laser resonator*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*understanding the rate equations to apply for lasers*	2	75	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-4:	*understand the conditions of stable resonators*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*understand the physics of higher harmonic generation*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*understand various types of lasers*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	General Introduction to lasers	Cavity life time and Quality factor	Geometrical optics analysis of optical resonators	Introduction to Q-switching	Coherence properties of laser light
	SLO-2	Spontaneous and stimulated emission Stimulated absorption	Ultimate line width of a laser	Condition for stable resonators	Dynamics of the Q-switching process	Temporal coherence
S-2	SLO-1	The laser idea	Einstein's A and B Coefficients	Stability diagram for optical resonators	Electro-optical Q-switching	Spatial coherence
	SLO-2	Gain medium, pumping scheme and optical feedback	Ratio of A and B at thermal equilibrium	Sources of resonator loss	Introduction to mode locking	Young's double slit experiment to understand spatial coherence
S-3	SLO-1	Properties of laser beams: Monochromaticity	Introduction to resonators	Laser rate equations	Mathematical interpretation for mode locking	Specific laser systems
	SLO-2	Directionality, coherence	Fabry-Perot cavity	Introduction to four level laser system	Mathematical interpretation for mode locking	Ruby laser
S-4	SLO-1	Modes of a cavity	Basic apparatus	Mathematical formulation of rate equations for four level laser system	Passive mode locking	He:Ne laser
	SLO-2	Black body radiation	Elementary theory of Fabry-Perot cavity	Mathematical formulation of rate equations for four level laser system	Active mode locking	Carbon dioxide laser
S-5	SLO-1	Black body radiation	Transmission spectrum of a Fabry-Perot cavity	Condition for population inversion	Concept of Gain saturation	Dye lasers, semiconductor lasers
	SLO-2	Calculation of mode density for black body	Coefficient of finesse/Quality factor	Threshold condition for four level system	Hole burning	DBR lasers
S-6	SLO-1	Calculating number of photons per mode for black body	Fundamental Gaussian beam	Calculating threshold for He-Ne laser	Spatial hole burning	Nd:YAG laser

	SLO-2	Comparison of black body radiation with laser radiation	Gaussian beam in homogeneous medium	Integrating cavity rate equation	Longitudinal and transverse mode selection	Higher harmonic generation
S-7	**SLO-1**	Line shape functions	Gaussian beam focusing	Rate equations under steady state condition	Single mode operation	Physics of harmonic generation
	SLO-2	Line-broadening mechanisms	Higher order Hermite Gauss beams	Variation of laser power around the threshold	Multi-mode lasers	Physics of harmonic generation
S-8	**SLO-1**	Homogeneous and Inhomogeneous broadening	Analysis of higher order Hermite Gauss beams	Optimum output coupling	Gain competition	Second harmonic generation
	SLO-2	Natural, Doppler and Collison broadening	Analysis of higher order Hermite Gauss beams	Laser spiking	Optical amplifiers	Third harmonic generation
S-9	**SLO-1**	Problems solving	Problems solving	Problem solving	Problem solving	Classification of lasers
	SLO-2	Problems solving	Problems solving	Problem solving	Problem solving	Laser safety

Learning Resources	1. K. Thyagarajan and A.K. Ghatak, Lasers Theory and Applications, 1st Ed., Macmilan Publishers, 2010. 2. O. Svelto, Principles of lasers, 4th Ed., Springer, 1998.	3. A. Yariv, Quantum Electronics, 3rd Ed., John Wiley, New York, 1989 4. Seigman, Lasers, 3rd Ed., Oxford Univ. Press, 1986. 5. B.E.A. Saleh and M.C. Teich, Fundamentals of Phtonics, 2nd Ed., Wiley, 2012.

Learning Assessment

	Bloom's Level of Thinking	**Continuous Learning Assessment (50% weightage)**								**Final Examination (50% weightage)**	
		CLA - 1 (10%)		CLA - 2 (10%)		CLA - 3 (20%)		CLA - 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. N Vijayan, NPL, nvijayan @nplindia.org	Prof. V Subramanian, IIT Madras, manianvs@iitm.ac.in	Dr. K Shadak Alee, SRMIST
Mr. R Seshadri, Titan Company Limited, seshadri@titan.co.in	Prof. C Vijayan, IIT Madras, cvijayan@iitm.ac.in	Dr. Junaid M Laskar, SRMIST

Course Code	PCY21G01T	Course Name	Research Skills and Learning	Course Category	G	Generic Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Understand the concept of research and different types of research in the context of chemistry	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	Evaluate the different methods of scientific writing and reporting																		
CLR-3 :	Impart the knowledge about the statistical distribution and applications																		
CLR-4 :	Develop the skill of technical writing																		
CLR-5 :	Inculcate the knowledge of intellectual property and rights																		
CLR-6 :	Understand the important areas of research																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Understand the key areas of research	2	75	60	H	H	H	L	H	H	H	H	H	L	H	H	H	H	H
CLO-2 :	Develop experimental skills and documentation	2	80	70	H	H	L	H	H	H	H	L	L	H	H	L	H	H	H
CLO-3 :	Develop competence on data collection and process of scientific documentation	2	70	65	H	H	M	M	H	L	H	L	L	H	H	L	H	H	H
CLO-4 :	Understand the research ethics	2	70	70	H	L	H	H	H	L	M	L	L	H	H	L	H	H	H
CLO-5 :	Submit proposals for funding agencies	2	80	70	H	H	H	M	M	H	H	L	L	H	H	L	H	H	H
CLO-6 :	Understand the key areas of research	2	75	70	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Objectives of research	Online databases	Analysis and Presentation of Data	Technical writing	Ethics in research
	SLO-2	Research methods and methodologies-Overview	E-journals, Journal acces	Descriptive statistics	Activity in Technical writing	authors Acknowledgement
S-2	SLO-1	types of research-Descriptive vs analytical	Citation index, Impact factor,	Choosing and using statistical tests	Technical presentation	Group discussion on ethics in research
	SLO-2	types of research - applied vs fundamental	H-index, E-consortium	Sample test - Student -t -test	Activity in Technical presentation	Outcome of group discussion
S-3	SLO-1	types of research-quantitative vs qualitative	UGC infonet, E-book	F- test	Creativity in research - Basic idea	Plagiarism
	SLO-2	types of research-conceptual vs empirical	Preprint servers	κ^2 test	Creativity in research - Activity	Tools to avoid plagiarism
S-4	SLO-1	Literature-review	Search engines, Scirus, Google Scholar	Chemometrics	Good practicals - Units, numbers	Presentations - Power-point presentation.
	SLO-2	Consolidation of Literature-review	ChemIndustry, Wiki-Databases	Analysis of variance (ANOVA),	Reproducibility	Poster presentation
S-5	SLO-1	Sources of information	ChemSpider, Science Direct	Correlation and regression	Scientific writing - Abbreviations	Elements of excellent presentation

Duration (hour)		9	9	9	9	9
	SLO-2	Primary, secondary, tertiary sources	SciFinder, Scopus	Curve fitting	nomenclature	Communication skills
S-6	SLO-1	Journal abbreviations, abstracts,	Internet resources for Science	fitting of linear equations,	justification for scientific contributions	Activity based on research presentation
	SLO-2	reviews, monographs, dictionaries	Library research,	analysis of residuals	description of methods	Activity based on research presentation
S-7	SLO-1	Introduction to Chemical Abstracts	field research	General polynomial fitting	conclusions	Proposal submission for funding agencies
	SLO-2	Author Index	Laboratory research	linearizing transformations	the need for illustration, style	Knowledge of funding agencies
S-8	SLO-1	Formula Index	Data Analysis - Making and Recording Measurements	exponential function fit,	Writing references	Intellectual property
	SLO-2	Subject Index	Continued.	r and its abuse	Research report writing	Intellectual property rights
S-9	SLO-1	Substance Index	Maintaining a laboratory record	Basic aspects of multiple linear regression analysis	Activity based on scientific writing	Copy rights
	SLO-2	other Indices with examples	Tabulation and generation of graphs	Basic aspects of multiple linear regression analysis	Activity based on scientific writing	Patent rights

Learning Resources	1. Dawson, C.. Practical research methods. UBS Publishers, New Delhi, 2002 2. Walpole R.A., Myers R.H., Myers S.L.and Ye King: Probablity and statstics for engineers and scientist, Pearson Prentice Hall, Pearson Education, Inc. 2007 3. 3. Kothari C.K., Research Methodology-Methods and Techniques(New Age International, New Delhi), 2004

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	50%	-	50%	-	50%	-	50%	-
	Analyze										
Level 3	Evaluate	30%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Expert from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Ravikiran Allada, Head R&D, Analytical, Novugen Pharma, Malaysia Email: ravianalytical@gmail.com	Prof. G. Sekar, Department of Chemistry, IIT Madras Email: Pgsekar@iitm.ac.in	Dr. T. Pushpa Malini, SRMIST
	Dr. Kanishka Biswas, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru Email: kanishka@jncasr.ac.in	Dr. J.Arockia Selvi, SRMIST

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Course Code	PCY21I01L	Course Name	*Massive Open Online Course*	Course Category	*P*	*Project Work, Internship In Industry / Higher Technical Institutions*	L	T	P	C
							0	0	0	2

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-1 :	*Encourage initiative by Govt. of India to achieve the three cardinal principles of access, equity and quality in different learning communities.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Demonstrate the knowledge and skill gained through learning of professional/elective courses taken on SWAYAM portal*	*2*	*75*	*60*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*Able to develop the professional skill on the subject areas beyond his curriculum*	*2*	*80*	*70*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3 :	*Experience unique and independent learning opportunity*	*2*	*70*	*65*	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4 :	*Expand his/her knowledge of a particular area(s) of interest to enhance employability*	*2*	*70*	*70*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Learning Assessment	*Student shall be allowed to choose one Swayam course on the recommendation of faculty advisor and appropriate credits will be transferred as per regulations 2021*
MOOC	

Course Code	PCY21I02L	Course Name	*Internship*	Course Category	*P*	*Project Work, Internship In Industry / Higher Technical Institutions*	L	T	P	C
							0	0	0	2

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Gain experience*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLR-2 :	*Have a better understanding*																		
CLR-3 :	*Have the opportunity to learn and watch.*																		
CLR-4 :	*Gain the ability to put new things into practice.*																		
CLR-5 :	*Build confidence*																		
CLR-6 :	*Get a feel for different working environment.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Improve the communication skill*	*2*	*75*	*60*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*recognize parallel relationship between words*	*2*	*80*	*70*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3 :	*Improve Professional behavior and/or knowledge*	*2*	*70*	*65*	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4 :	*Improve the Project-related skills*	*2*	*70*	*70*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Improve employability-enhancing activities*	*2*	*80*	*70*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6 :	*Develop personal networking*	*2*	*75*	*70*	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

	Continuous Learning Assessment (50% weightage)		Final Evaluation (50% weightage)	
	Review - 1	Review - 2	Project Report	Viva-Voce
Internship	20%	30 %	30 %	20 %

Course Code	PCD21AE3T	Course Name	Employability Skills	Course Category	AE	Ability Enhancement Course	L	T	P	C
							1	0	0	1

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Career Development Centre			Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*Develop contextual approach to acquire new vocabulary*
CLR-2:	*Establish clear relationship between words*
CLR-3:	*Identify problems*
CLR-4:	*Learn the fundamental skills to solve problems*
CLR-5:	*Acquire experience of attending group discussion and personal interview*
CLR-6:	*Equipping students with necessary employability skills*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1:	*Determine the accurate meanings of words*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-2:	*Recognise parallel relationship between words*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-3:	*Learn to solve problems*	2	75	70	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H
CLO-4:	*Understand and applies problem solving skills learned.*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-5:	*Inculcate professional communication through Interviews & Group Discussions*	2	80	70	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H
CLO-6:	*Acquirenecessary skills for successful career*	2	80	75	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H

Duration (hour)		3	3	3	3	3
S-1	SLO-1	Time & work	Time, speed, distance	Permutation and combination	Probability	Geometry and Mensuration
	SLO-2	Solving problems	Solving problems	Solving problems	Solving problems	Solving problems
S-2	SLO-1	Perspective on Issues	Critical Reasoning	Synonyms	Antonyms	Word Analogy
	SLO-2	Perspective on Issues	Critical Reasoning	Synonyms	Antonyms	Word Analogy
S-3	SLO-1	Resume preparation	Group Discussion	Mock GD	Interview Techniques	Mock PI
	SLO-2	Resume preparation	Group Discussion	Mock GD	Interview Techniques	Mock PI

Learning Resources	1. Quantitative aptitude by Dinesh Khattar 2. Ramachandran and Karthik, From Campus to Corporate, India, PEARSON Publication, 2016.	3. Verbal Advantage - Ten Easy Steps to a Powerful Vocabulary - Charles Harrington Elster 4. Barron's GRE

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA - 1 (10%)		CLA - 2 (10%)		CLA - 3 (20%)		CLA - 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	30 %	-	30 %	-	30 %	-	30 %	-	30 %	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Scientific Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications etc.,

Course Designers		
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	7. Mrs. Kavitha Srisarann, SRMIST	

Semester-IV

Course Code	PCY21P01L	Course Name	Project Work	Course Category	P	*Project Work, Internship In Industry / Higher Technical Institutions*	L	T	P	C
							0	0	24	12

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemistry*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Produce competent, creative and imaginative graduates with a strong scientific acumen*																		
CLR-2 :	*Apply of the acquired knowledge, skills, and tools pertinent to the field of Chemistry*																		
CLR-3 :	*Promote independent and collaborative research work in the domain of chemistry*																		
CLR-4 :	*Inculcate the ethical responsibility of the graduate in the scientific society*																		
CLR-5 :	*Identify the challenges and solutions pertinent to the field of Chemistry*																		
CLR-6 :	*Promote development of intellectual property by publishing articles in high impact factor journals, conference proceedings, patents*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO -1	PSO -2	PSO-3
CLO-1 :	*Demonstrate knowledge of contemporary issues in their chosen field of research*	*2*	*75*	*60*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Demonstrate an ability to present and defend their research work to a panel of experts*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*
CLO-3 :	*Communicate with scientist and the community at large in written an oral forms*	*2*	*70*	*65*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*
CLO-4 :	*Undertake problem identification, formulation and solution.*	*2*	*70*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Complete an independent research project with the research outputs in terms of publications in journals, conference proceedings and patents.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Find solutions to complex scientific problems in a systematic approach*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

	Continuous Learning Assessment (50% weightage)		Final Evaluation (50% weightage)	
	Review - 1*	Review - 2*	Project Report*	Viva-Voce
Project Work	20%	30 %	30 %	20 %

*includes submission of project work in the form of paper for presentation/publication in a conference/journal and/or preliminary filing of a patent with proof.

GENERIC ELECTIVE OFFERED BY THE CHEMISTRY DEPARTMENT

Course Code	PCY21G02T	Course Name	Chemistry of Biomolecules	Course Category	G	Generic elective course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemistry	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	Develop a sound knowledge of the fundamental concepts in bio-organic chemistry	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Disciplinary Knowledge	Critical Thinking	Problem Solving	Analytical Reasoning	Research Skills	Team Work	Scientific Reasoning	Reflective Thinking	Self-Directed Learning	Multicultural Competence	ICT Skills	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	Provide basic understanding about the biomolecules like aminoacids, proteins, nucleic acids, lipids and carbohydrates																		
CLR-3 :	Appreciate the role of these biomolecules in biology.																		
CLR-4 :	Gain knowledge about enzymes and coenzymes																		
CLR-5 :	Apply the information gained about enzymes and coenzymes into organic chemistry applications like molecule synthesis																		
CLR:6:	Gain knowledge about amino acids and proteins and their structural features																		
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:																		
CLO-1 :	Inculcate the organic chemistry knowledge to gain insight into biomolecule systems	*2*	*75*	*60*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	Apply the information gained about enzymes and coenzymes into organic synthesis.	*2*	*80*	*70*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-3 :	Understand the importance of nucleic acid in bioorganic chemistry	*2*	*70*	*65*	*H*	*H*	*M*	*M*	*H*	*L*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-4:	Understand the importance of carbohydrate chemistry	*2*	*70*	*70*	*H*	*L*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-5:	Understand the significant role of amino acid, peptides and proteins in bioorganic chemistry	*2*	*80*	*70*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*L*	*L*	*H*	*H*	*L*	*H*	*H*	*H*
CLO-6:	Understand interactions between amino acids, peptides, nucleic acids and there role in biomolecule structure	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		(9)	(9)	(9)	(9)	(9)
S-1	**SLO-1**	Classification and structure of amino acids	Enzymes, Classification	Nature of genetic material	Fatty acids classification	Classification of carbohydrates
	SLO-2	Classification and structure of amino acids	Enzymes, Classification	Nature of genetic material	Fatty acids classification	Classification of carbohydrates
S-2	**SLO-1**	Configuration of amino acids, acid-base properties and isoelectric point	Kinetics, inhibition	Structure of purine and pyrimidine	Nomenclature, structureof fatty acids	Stereo isomerism of sugars
	SLO-2	Configuration of amino acids, acid-base properties and isoelectric point	Kinetics, inhibition	Structure of purine and pyrimidine	Nomenclature, structureof fatty acids	Stereo isomerism of sugars
S-3	**SLO-1**	Separation of amino acids	Mechanisms of enzyme action	Nucleotides and nucleosides	Properties of fatty acids	Optical isomerism of sugars
	SLO-2	Separation of amino acids	Mechanisms of enzyme action	Nucleotides and nucleosides	Properties of fatty acids	Optical isomerism of sugars

S-4	**SLO-1**	Peptide bonds, disulfide linkages	Cofactors as derived from vitamins, co-enzymes	Types of nucleic acids	Structure and function of prostaglandins, tri-acyl glycerol	Mutarotation, occurrence,
	SLO-2	Peptide bonds, disulfide linkages	Cofactors as derived from vitamins, co-enzymes	Types of nucleic acids	Structure and function of prostaglandins, tri-acyl glycerol	Mutarotation, occurrence,
S-5	**SLO-1**	Proteins classification based on solubility, shape, composition and function,	Prosthetic, prosthetic group and apoenzymes	Structure of DNA	Structure and functions of phospholipids,	Structure of mono and di saccharides
	SLO-2	Proteins classification based on solubility, shape, composition and function,	Prosthetic, prosthetic group and apoenzymes	Structure of DNA	Structure and functions of phospholipids,	Structure of mono and di saccharides
S-6	**SLO-1**	Structure of polysaccharides	Structure and biological functions of coenzyme-A	Properties of nucleic acids	Spingomyelin	Biological importance of mono, di and polysaccharides
	SLO-2	Structure of proteins	Structure and biological functions of coenzyme-A	Tm, denaturation and renaturation	Spingomyelin	Biological importance of mono, di and polysaccharides
S-7	**SLO-1**	Structure of proteins	Thiamine pyrophosphate, pyridoxal phosphate	Hypo and hyperchromicity	Plasmologens	An introduction to mucopolysaccharides
	SLO-2	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures	Thiamine pyrophosphate, pyridoxal phosphate	Basic ideas on replication	Plasmologens	An introduction to mucopolysaccharides
S-8	**SLO-1**	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures	NAD+, NADP+	Transcription and translation	Structure and function of glycolipids	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups
	SLO-2	Determination of the primary structure of a protein, secondary, tertiary and quaternary structures	FAD, lipoic acid	Transcription and translation	Structure and function of glycolipids	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups
S-9	**SLO-1**	Protein denaturation	Overview of reactions catalysed by the above cofactors	Determination of the base sequence of DNA	Cholesterol.	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups
	SLO-2	Protein denaturation	Overview of reactions catalysed by the above cofactors	Determination of the base sequence of DNA	Cholesterol.	Reactions of carbohydrates due to the presence of hydroxyl, aldehyde and ketone groups

Learning Resources	1.D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 5thEd., W. H. Freeman; New York, USA, 2005. 2. R. K. Murray, D. K. Grammer, Harper's Biochemistry, 29th Ed., McGraw Hill, Lange Medical Books, United Kingdom, 2009. 3. J.L. Jain, S. Jain, N. Jain, Fundamentals of Biochemistry, S. Chand & Company. India, 2013. 4. P. Y. Bruice, Organic Chemistry, 5th Ed., Pearson, 2014.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (10%)		CLA – 3 (20%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	30%	-	30%	-	30%	-	30%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	30%	-	30%	-	30%	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA - 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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