DEPARTMENT OF CHEMISTRY				*CLASS: I M.Sc. Chemistry*				
Sem	**Course Type**	**Course Code**	**Course Title**	**Credits**	**Contact Hours/week**	**CIA**	**Ext**	**Total**
II	Major Elective-II	21P2CME2	Synthetic methods, Green Chemistry & Renewable energy	4	5	25	75	100

Nature of Course				
Knowledge and skill	✓		Employability oriented	
Skill oriented	✓		Entrepreneurship oriented	

Objectives: *The objective of this course is to make the student*

(i) To know the various modern synthetic strategies through retrosynthetic analysis and by tandem processes.
(ii) To use the appropriate reagents for the effective conversion.
(iii) To explore the knowledge of asymmetric synthesis and total synthesis of natural products
(iv) To know the importance and applications of green chemistry techniques
(v) To understand the need of renewable energy resources

Unit	Description	Hours	K-Level	CLO
I	**Synthetic Methodology** Umpolung, 1,3-Dipolar cycloaddition methodologies (Azide, nitrile oxide, azomethine ylides and carbonyl ylides). Concept of Tandem, cascade and domino reactions in organic synthesis. Protection and deprotection techniques for amines, carboxylic acids, carbonyl and hydroxyl groups. Retero synthetic methods: Synthons (acceptor and donor) - Retrosynthetic analysis - Disconnection approach – functional group interconversion, the importance of order of events in organic synthesis, one C-X, and two-group C-X disconnections, Self-study: Various types of cyclization and ring formation reaction: anionic, cationic, radical and transition metal mediated cyclizations.	15	Up to K4	CLO-1
II	**Novel Reagents & Asymmetric synthesis** Role of palladium and nickel catalysts in organic reactions including Pd (0), Ni (0), Pd (II) and Ni (II) complexes. Typical reactions involving Heck, Negishi, Suzuki-Miyaura, Kumada, Sonogashira, Stille and Hiyama coupling for carbon-carbon bond formation reactions. Selectivity: Chemo- regio- stereo- Resolution - Kinetic resolution reactions, Desymmetrization, Asymmetric induction, Chiral auxiliary. Generation of Asymmetric synthesis – Substrate –	15	Up to K4	CLO-2

	Auxiliary - Reagent and Catalyst control. Auxiliary controlled alkylation of chiral enolates, Enders RAMP/SAMP and chiral sulfoxide. Asymmetric oxidation [dihydroxylation, epoxidation Sharpless, Jacobsen, Shi]. Self-study: Buchwald-Hartwig coupling for the carbon-heteroatom bond formation reactions. Asymmetric reduction (Noyori, Corey, Pfaltz) - Boranes reduction.			
III	**Total synthesis of natural products** Alkaloids and Terpenoids: Classification, isolation and general methods of determining structure - Demonstration of various types of total syntheses using alkaloid (Epibatidine and Ibogamine), Prostaglandin (PGE1) and Terpenes (longifolene, cedrene and Jasmone).	15	Up to K4	CLO-3
IV	**Green Chemistry** Introduction to green chemistry - definition, origin, history, needs, goals, twelve principles of green chemistry. Usage of Conventional and Green solvents - Advantages, Limitations and drawbacks. Green Synthesis – Designing, Choice of starting materials, choice of reagents, choice of catalysts: bio catalysts, polymer supported catalysts, choice of solvents. Synthesis involving basic principles of green chemistry. Examples: synthesis of adipic acid, methyl methacrylate, paracetamol. Microwave, Ultrasonication and Ultrasound assisted reactions – esterification, reduction and coupling reactions.	15	Up to K3	CLO-4
V	**Renewable energy resources** Renewable energy sources: types of renewable energy sources. Solar cells: basic principles, types and their applications. Fuel cells: basic principles, types and their applications. Working principle and applications of Biofuel cells - brief introduction about hydroelectric, biomass, wind power and geothermal power and their applications and limitations-energy from some other natural source.	15	Up to K2	CLO-5

Books for study:

1. Finar, I.L., "Organic Chemistry", Vol. II, Sixth Edition, Pearson Education Pvt. Ltd., Singapore, 2006.
2. Smith, M. B., "Organic Synthesis", Second Edition, McGraw-Hill International Edition, New Delhi, 1994.
3. Sanghi, R. and Srivastava, M.M., "Green Chemistry (Environmental FriendlyAlternatives)", First Edition, Narosa Publishing House, New Delhi, 2003. PG

Books for reference:

1. Ahluvalia, V.K., "Chemistry of Natural Products", First Edition, Vishal Publishing Co, Jalandhar, 2008.
2. Carrutherus, W., "Some Modern Methods in Organic Synthesis", Third Edition, Cambridge University Press, New York, 1997.

3. Nasipuri, M., “Stereochemistry of Organic Compounds”, Third Edition, New Age International, New Delhi, 2007.
4. Norman, R. and Coxon, J. M. Principles of Organic Synthesis, Blackie Academic & Professional, 1988.
5. Eliel, E.L., “Stereochemistry of Carbon Compounds”, First Edition, McGraw Hill, New Delhi, 2007.
6. Warren, S. Wyatt, P. “Organic Synthesis: The Disconnection Approach”, 2nd edition, Wiley & Sons Ltd., 2008.

Web resources:

1. https://nptel.ac.in/courses/104/105/104105087/
2. https://nptel.ac.in/courses/104/103/104103111/
3. https://nptel.ac.in/courses/104/103/104103067/
4. https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry.html
5. https://www.sciencedirect.com/topics/chemistry/green-chemistry

Rationale for Nature of the course

This course will enable the students to comprehend the ideas of synthetic methods for synthesizing chiral/achiral molecules and can help them to disconnect the new target molecule. It inculcates the green techniques, total synthesis and ideas about renewable energy resources.

Activities having direct bearing on Skill development/ Employability/Entrepreneurship

Retro synthetic analysis, green chemistry principles and techniques will impart skills that can be used to design new molecules in green manner. The knowledge of reagents and energy resources will be used for molecules transformations and alternate sources of energy.

Pedagogy:

- Chalk-Talk Class room Activities
- Seminar
- Assignment and Quiz through ICT

Lesson Plan

Unit	Topics	Hours	Mode
I	Umpolung, 1,3-Dipolar cycloaddition methodologies (Azide, nitrile oxide, azomethine ylides and carbonyl ylides)	3	PPT, Chalk and talk, Assignment
	Concept of Tandem, cascade and domino reactions in organic synthesis.	3	
	Protection and deprotection techniques for amines, carboxylic acids, carbonyl and hydroxyl groups.	2	
	Synthons (acceptor and donor) - Retrosynthetic analysis - Disconnection approach	2	
	Functional group interconversion, the importance of order of events in organic synthesis	3	
	one C-X, and two-group C-X disconnections	2	
II	Role of palladium and nickel catalysts in organic reactions including Pd (0), Ni (0), Pd (II) and Ni (II) complexes.	3	PPT, Chalk and talk, Assignment
	Typical reactions involving Heck, Negishi, Suzuki-Miyaura, Kumada, Sonogashira, Stille and Hiyama coupling for carbon-carbon bond formation reactions.	3	
	Selectivity: Chemo- regio- stereo- Resolution - Kinetic resolution reactions, Desymmetrization, Asymmetric induction,	3	
	Chiral auxiliary. Generation of Asymmetric synthesis – Substrate – Auxiliary - Reagent and Catalyst control.	2	
	Auxiliary controlled alkylation of chiral enolates, Evans oxazolidones, chiral hydrozones and chiral imines.	2	
	Enders RAMP/SAMP and chiral sulfoxide. Asymmetric oxidation [dihydroxylation, epoxidation Sharpless, Jacobsen, Shi]	2	
III	Alkaloids and Terpenoids: Classification, isolation and general methods of determining structure	2	PPT, Chalk and talk, Assignment
	Demonstration of various types of total syntheses using alkaloid (Epibatidine and Ibogamine)	5	
	Prostaglandin (PGE1)	2	
	Terpenes (longifolene, cedrene)	4	
	Jasmone	2	
IV	Introduction to green chemistry - definition, origin, history, needs, goals, twelve principles of green chemistry.	3	PPT, Chalk and talk, Group discussion
	Usage of Conventional and Green solvents - Advantages, Limitations and drawbacks.	2	
	Green Synthesis – Designing, Choice of starting materials, choice of reagents, choice of catalysts: bio catalysts, polymer supported catalysts, choice of solvents.	4	
	Synthesis involving basic principles of green chemistry. Examples: synthesis of adipic acid, methyl methacrylate, paracetamol.	3	
	Microwave, Ultrasonication and Ultrasound assisted reactions – esterification, reduction and coupling reactions.	3	
V	Renewable energy sources: types of renewable energy sources.	2	PPT, Chalk and talk, Group discussion
	Solar cells: basic principles, types and their applications.	2	
	Fuel cells: basic principles, types and their applications.	2	
	Working principle and applications of Biofuel cells	2	
	brief introduction about hydroelectric, biomass, wind power and geothermal power and their applications and limitations	4	
	energy from some other natural source	3	

Course Learning outcome: After successful completion of this course, the student will be able to

CLOs	CLO statement	Knowledge level
CLO1	Devise the disconnection of a given organic molecule and can find the synthetic equivalents and synthetic route.	Up to K4
CLO2	Connect the knowledge of reagents for chemical transformations and discover the nature of chirality	Up to K4
CLO3	Illustrate the knowledge of structural elucidation for a natural product.	Up to K4
CLO4	Apply green chemistry techniques for a given conventional thermal reactions	Up to K3
CLO5	Identify the alternative energy resources for chemical conversions	Up to K2

Mapping of CLOs with PLOs

#	PLO–1	PLO–2	PLO- 3	PLO–4	PLO–5
CLO–1	2		3		
CLO–2	2		2		
CLO–3	2		2	2	
CLO–4	2		2	2	
CLO–5	2			2	

Advance application– 3; Intermediate level–2; Basic level–1

Components of Formative Assessment	Marks	K level
Internal Test	**10**	As per below table
Assignment	**5**	K4
Quiz	**5**	K4
Seminar	**5**	K4
Total	**25**	

Learning Outcome Based Education (LOBE) & Assessment
Formative Examinations I & II – Blue Print
Articulation Mapping-K Levels with Courses Learning Outcomes (CLOs)

Units	CLOs	K- Level	SectionA		Section B (Either/or Choice)	Section C (Open Choice)
			Short Answers			
			No. of Questions	K- Level		
1	CLO x	Up to K3	2	K2,K3	2 (K3&K3)	2(K2/K3)
2	CLO y	Up to K4	3	K2, K2, K3	2 (K4&K4)	1(K3/K4)
No. of Questions to be asked			5		4	3
No. of Questions to be answered			5		2	2
Marks for each question			2		5	10
Total Marks for each section			10		10	20

K1- Remembering and recalling facts with specific answers
K2- Basic understanding of facts and stating main ideas with general answers
K3- Application oriented- Solving Problems
K4- Examining, analyzing, presentation and make inferences with evidences

Learning Outcome Based Education (LOBE) & Assessment
Summative Examination – Blue Print
Articulation Mapping-K Levels with Courses Learning Outcomes (CLOs)

S. No.	CLOs	K- Level	Section A		Section B		Section C (Either/or Choice)	Section D (Open Choice)
			MCQs		Short Answers			
			No. of Questions	K- Level	No. of Questions	K- Level		
1	CLO 1	Up to K4	2	K3 & K4	1	K3	2 (K4 & K4)	1(K4)
2	CLO 2	Up to K4	2	K3 & K4	1	K2	2 (K4 & K4)	1(K4)
3	CLO 3	Up to K4	2	K2 & K3	1	K2	2 (K3 & K3)	1(K3)
4	CLO 4	Up to K3	2	K2& K3	1	K1	2 (K2& K2)	1(K3)
5	CLO 5	Up to K2	2	K1& K1	1	K1	2 (K1& K1)	1(K2)
No. of Questions to be asked			10		5		10	5
No. of Questions to be answered			10		5		5	3
Marks for each question			1		2		5	10
Total Marks for each section			10		10		25	30

K1- Remembering and recalling facts with specific answers
K2- Basic understanding of facts and stating main ideas with general answers
K3- Application oriented- Solving Problems
K4- Examining, analyzing, presentation and make inferences with evidences

Distribution of Section-wise Marks with K Levels

K Levels	Section A& B (No Choice)	Section C (Either / or)	Section D (Open Choice)	Total Marks	% of Marks without choice	Consolidated %
K1	6	10	-	16	13.3	35
K2	6	10	10	26	21.7	
K3	6	10	20	36	30	30
K4	2	20	20	42	35	35
Total marks	**20**	**50**	**50**	**120**	**100**	**100%**

Name of the course Designer

- Dr. S. V. Karthikeyan