School of Chemistry
Faculty of Science
University of the Punjab, Lahore
Course Outline

BS Chemistry Semester-III					
Programme	**BS Chemistry**	**Course Code**	**Chem-291**	**Credit Hours**	**2**
Course Title	**Introduction to Green Chemistry**		**Course Type**	**Major Elective**	

Course Introduction

This course presents the fundamentals of green chemistry and the science behind sustainability issues with efforts that can be taken to create solutions. Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. While there are many mechanisms and tools available to assess the impact of materials and processes on human health and the environment, there are few tools available to help design and create products as such. The course contents are provided below.

Introduction to Green Chemistry, principles of Green Chemistry; waste reduction, atom economy, non-hazardous syntheses, safe chemicals and solvents, minimal energy consumption, renewable energy consumption, renewable raw materials, simple chemistry, catalysis, degradability, real-time analysis, and accident prevention.

Learning Outcomes

On the completion of the course, the students will be able to:

1. Demonstrate a broader and deeper understanding of the twelve principles of green chemistry
2. Evaluate technologies and products by applying the methods and tools of green chemistry in the practice of chemistry.
3. Evaluate, whether a chemical transformation can be classified as environment friendly and sustainable, or which parameters need to be optimized in order to achieve this.
4. Explain how the application of green chemistry principles can address sustainability issues.

Course Content		Assignments/Readings
Week 1	What is green chemistry? The origin and background of green chemistry	Related reading
Week 2	Why green chemistry is called sustainable chemistry? Concept of 4R's.	Related reading
Week 3	Significance, goals and limitations of green chemistry	Related reading
Week 4	An overview of principles of green chemistry	Related reading
Week 5	Waste reduction and atom economy	Related reading
Week 6	Non-hazardous synthesis	Related reading
Week 7	Green solvents and safe chemicals	Related reading
Week 8	**Mid-term Examination**	
Week 9	Energy efficient processes	Related reading
Week 10	Renewable energy consumption	Related reading
Week 11	Use of renewable raw materials	Related reading
Week 12	Catalysis and use of catalytic reagents	Related reading

Week 13	Reduce derivatives or minimization of steps (simple chemistry) and design for degradability	Related reading
Week 14	Accident Prevention and real time analysis	Related reading
Week 15	Current trends, developments and innovations in green chemistry	Related reading
Week 16	**Final term Examination**	

Textbooks and Reading Material

1. Sankar P. Day, Nayim Sep, (2021), *A Textbook of Green Chemistry, Edition 1st,* Techno World Publisher.
2. M. Lancaster, (2016), *Green Chemistry: An Introductory Text, Edition 3,* RSC Publishers.
3. P. Anastas and P. Trevorrow, (2013), *Handbook of Green Chemistry, Green Processes, Designing Safer Chemicals,* Wiley Publishers.
4. A. Lapkin and D. Constable, (2008), *Green Chemistry Metrics: Measuring and Monitoring Sustainable Processes,* Wiley Publishers.
5. J. H. Clark, A. Hunt, C. Topi, G. Paggiola and J. Sherwood, (2017), *Sustainable Solvents: Perspectives from Research, Business and International Policy (Green Chemistry Series),* RSC Publishers.

Teaching Learning Strategies

Class lecture method, which includes seminars, discussions, assignments and projects. Audio-visual tools will be used where necessary

Assignments: Types and Number with Calendar

1. Written Task
2. Presentation
3. Tutorials
4. Solving related exercises

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

BS Chemistry Semester-III					
Programme	**BS Chemistry**	**Course Code**	**Chem-292**	**Credit Hours**	**1**
Course Title	**Green Chemistry Laboratory**		**Course Type**	**Major Elective**	

Course Introduction

Green Chemistry Laboratory course is designed to teach students the tools and strategies to improve the chemical reaction and process using the principles of green chemistry. Students will conduct experiments that emphasize sustainable practices, such as reducing waste, using safer solvents and reagents, and improving process efficiency. The laboratory sessions will also focus on evaluating the environmental impact of various chemical processes and developing innovative solutions.

The course contents are provided below.

Overview of laboratory safety and green chemistry principles. Solvent free green synthesis of coumarin (Knoevenagel/Pechmann/ suitable condensation reaction). Synthesis of quaternary ammonium salts. Recycling of renewable waste (use of hair/feather waste for keratin extraction or any suitable recycling experiment). Green synthesis of metal or metal oxide nanoparticles of Ag/Cu/Zn. Reduction of dyes using green reducing agents. Heterogeneous catalysis for oxime formation.

Learning Outcomes

On the completion of the course, the students will:

1. Identify the tools and strategies to improve the chemical reaction and process using the principles of green chemistry.
2. Explain how the practice of green chemistry enhances competitiveness, innovation and faster time to market, while addressing critical ethical and sustainability issues.
3. Students will be aware of the social, ecological and economic dimensions with responsibility of the profession of chemist.

Course Content		Assignments/Readings
Week 1	Overview of laboratory safety and green chemistry principles	Related reading
Week 2	Solvent free green synthesis of coumarin (knoevenagel/Pechmann/ suitable condensation reaction)	Related reading
Week 3	Solvent free green synthesis of coumarin (Knoevenagel/Pechmann/ suitable condensation reaction)	Related reading
Week 4	Synthesis of quaternary ammonium salts	Related reading
Week 5	Synthesis of quaternary ammonium salts	Related reading
Week 6	Recycling of renewable waste (use of hair/feather waste for keratin extraction or any suitable recycling experiment)	Related reading
Week 7	Recycling of renewable waste (use of hair/feather waste for keratin extraction or any suitable recycling experiment)	Related reading
Week 8	**Mid-term Examination**	
Week 9	Green synthesis of metal or metal oxide	Related reading

	nanoparticles of Ag/Cu/Zn	
Week 10	Green synthesis of metal or metal oxide nanoparticles of Ag/Cu/Zn	Related reading
Week 11	Green synthesis of metal or metal oxide nanoparticles of Ag/Cu/Zn	Related reading
Week 12	Reduction of dyes using green reducing agents	Related reading
Week 13	Reduction of dyes using green reducing agents	Related reading
Week 14	Heterogeneous catalysis for oxime formation	Related reading
Week 15	Heterogeneous catalysis for oxime formation	Related reading
Week 16	**Final term Examination**	

Textbooks and Reading Material

1. Sally A. Henrie, (2015), *Green Chemistry-Laboratory Manual for General Chemistry*, Taylor & Francis CRC Press.
2. Syed Kazim Moosvi, Waseem Gulzar Naqash, Mohd. Hanief Najar, (2021), *Green Chemistry Principles and Designing of Green Synthesis*, De Gruyter publishers.
3. P. Anastas and P. Trevorrow, (2013), *Handbook of Green Chemistry, Green Processes, Designing Safer Chemicals*, Wiley Publishers.
4. A. Lapkin and D. Constable, (2008), *Green Chemistry Metrics: Measuring and Monitoring Sustainable Processes*, Wiley Publishers.
5. Anastas, Paul T, and John C Warner (2000), *Green Chemistry: Theory and Practice*, Oxford Academic Press.

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