Spring 2025: Chem 702 Green Chemistry & Sustainability

NJIT New Jersey Institute of Technology

THE COLLEGE OF SCIENCE AND LIBERAL ARTS

THE DEPARTMENT OF CHEMISTRY AND ENVIRONMENTAL SCIENCE

Course Syllabus

3 credits, Wednesdays from 6:00 – 8:50 PM, KupF 203

INSTRUCTOR: Dr. Gaddi Eshun, Office Hours: Wednesdays @ 3:00 – 4:30PM, via Zoom

Course Description

This course provides an interdisciplinary perspective that includes chemists, economists, environmental engineers, and social scientists as instructors. The course integrates Green Chemistry with Sustainability, emphasizing societal, economic, environmental, and governance (SEEG) perspectives. Students will learn: i) how to design products and processes that minimize or eliminate the production and use of hazardous substances, ii) the 12 principles of Green Chemistry, and iii) how these principles can be used to develop sustainable catalysts, green solvents, degradable materials, reduce waste, reuse materials, and design safer processes, and products while ensuring sustainability. In addition, students will have the opportunity to interact with leaders of Green Chemistry & sustainability, as well as learn about success stories, toxicology, microbial degradation, and greener pharmaceutical designs for recycling, degradation, and other contemporary topics.

Prerequisites: Basic understanding of introductory general chemistry

Course Objectives

This course will broaden students' understanding of the issues to which advanced training in chemistry can be applied and simultaneously increase their ability to formulate critical research questions on the daunting challenges of the 21st century concerning food, energy, and human and planetary health. Sustainability and sustainable development are desirable characteristics of today's industrial society. Not only do we need resources and successful economic development to achieve sustainability goals, but we also need to limit the impacts of human activities on the Earth's ecosystems and the global environment. Green Chemistry has great promises for sustainable development.

Delivery Format: Class lectures, participation in CES Department colloquia on relevant topics, and Right Question Institute Workshop, classroom visits by Green Chemistry and Sustainability luminaries, group discussions, and videos.

Number of Credits: 3

Learning outcomes

- Understand the need and role of chemicals in society
- Learn the chemical disasters that occurred in the past and their causes.
- Qualitatively and quantitatively examine the impacts of chemical products and processes on human health and the environment.
- Understand 12 principles of Green chemistry and identify their individual impact.
- Understand how Green chemistry can be used to reduce waste, reuse materials, design safer processes and products, and ensure sustainability.
- Apply green chemistry principles before and during experiments.
- Evaluate atom economy, E-factor, process mass intensity, and differentiate between percentage yield and atom economy.
- Perform Life cycle assessment of commercialized products.
- Learn basic concepts of toxicology.
- Analyze materials, their properties, toxicity, and regulatory requirements before using them in any process and finding safer substitutes.
- Develop skills and analyze alternative routes for conventional procedures requiring toxic substances.
- Appreciate SEEG perspectives and how green chemistry is transforming chemistry on a global scale and advancing UN Sustainable Development Goals.
- Appreciate the success stories and real cases that employed green chemistry.
- Recognize the importance of analytical methods in the real-time monitoring of a chemical product and process.

Assessment of Learning Outcomes

Grading Policy: The final grade in this course will be determined as follows:

A	100 - 90% (Superior)	**C**	77 – 70% (Acceptable)
B+	87 - 89 % (Excellent)	**D**	69 - 65 % (Inadequate)
B	86 - 80 % (Very Good)	**F**	Below 65 % (Failed)
C+	77 - 79% (Good)		

Grading Criteria

Exam 1	15 points
Exam II	15 points
Final Exam	20 points
*Group Discussion/Class Participation	20 points

Term Paper and Class Presentation	30 points
Total	100 points

*Students must submit their contributions to the group discussion for grading at the end of each group session. All submissions must be on Canvas, no emails!

Once grades are assigned, they will not be changed under any circumstances unless there is a computational error. To be fair to all students, no additional assignments will be given to urgent or adjusted grades.

University Calendar

January 20	Monday	Martin Luther King, Jr. Day
January 21	Tuesday	First Day of Classes
January 25	Saturday	Saturday Classes Begin
January 27	Monday	Last Day to Add/Drop a Class
January 27	Monday	Last Day for 100% Refund, Full or Partial Withdrawal
January 28	Tuesday	W Grades Posted for Course Withdrawals
February 3	Monday	Last Day for 90% Refund, Full or Partial Withdrawal, No Refund for Partial Withdrawal after this date
February 17	Monday	Last Day for 50% Refund, Full Withdrawal
March 10	Monday	Last Day for 25% Refund, Full Withdrawal
March 16	Sunday	Spring Recess Begins - No Classes Scheduled - University Open
March 22	Saturday	Spring Recess Ends
April 3	Thursday	Wellness Day - No Classes Scheduled - University Open
April 7	Monday	Last Day to Withdraw
April 18	Friday	Good Friday - No Classes Scheduled - University Closed
April 20	Sunday	Easter Sunday - No Classes Scheduled - University Closed
May 6	Tuesday	Thursday Classes Meet
May 7	Wednesday	Friday Classes Meet
May 7	Wednesday	Last Day of Classes
May 8	Thursday	Reading Day 1
May 9	Friday	Reading Day 2
May 10	Saturday	Final Exams Begin
May 16	Friday	Final Exams End
May 18	Sunday	Final Grades Due

May 19 Monday Master's and PhD Candidate Commencement - Bloom Wellness and Events Center

May 21 Wednesday Undergraduate Candidate Commencement - Prudential Center

Contacting the Instructor: The best method to contact me is by email at gbe4@njit.edu. Please use your NJIT email to contact me. Allow a 24 hour duration for a response

CAVEAT: The instructor reserves the right to change or revise the syllabus during the term in consultation with students.

ACADEMIC INTEGRITY

NJIT Academic Integrity Code: All students should be aware that the Department of Chemistry & Environmental Science (CES) takes the University Code on Academic Integrity at NJIT very seriously and enforces it strictly. This means that there must not be any forms of plagiarism, i.e., copying of homework, class projects, or lab assignments, or any form of cheating in quizzes and exams. Under the University Code on Academic Integrity, students are obligated to report any such activities to the instructor.

As a member of the NJIT community, you are responsible for protecting your investment by knowing and following the academic integrity policy that is found at https://www.njit.edu/dos/code-student-conduct-article-11-university-policy-academic-integrity. Please be aware that I have the professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Anyone who violates the code of conduct by cheating, plagiarizing, or inappropriately using any online software will face disciplinary action. Such actions may include a failing grade of automatic F and/or suspension or dismissal from the university. Please contact the Dean of Students Office for further questions or policy information (dos@njit.edu).

If any examination is compromised, I reserve the right to retest the whole class or any individual in the class. Students are expected to comply with the University Honor Code.

Makeup Exam Policy: There will normally be **NO MAKE-UP QUIZZES OR EXAMS** during the semester. In the event that a student has a legitimate reason for missing a quiz or exam, the student should contact the Dean of Students office and present written verifiable proof of the reason for missing the exam, e.g., a doctor's note, police report, court notice, etc. clearly stating the date AND time of the mitigating problem. The student must also notify the CES Department Office/Instructor that the exam will be missed so that appropriate steps can be taken to make up the grade.

Cellular Phones: All cellular phones and other electronic devices must be switched off during all class times. Such devices must be stowed in bags during exams or quizzes.

ADDITIONAL RESOURCES

Chemistry Tutoring Center: Located in the Central King Building, Lower Level, Rm. G12. Hours of operation are Monday – Friday 10:00 am - 6:00 pm. For further information please click here.

Accommodation of Disabilities: The **O**ffice of **A**ccessibility **R**esources and **S**ervices offers long-term and temporary accommodations for undergraduate, graduate and visiting students at NJIT.

If you are in need of accommodations due to a disability, please get in touch with Marsha Williams-Nicholas, Associate Director at the Office of Accessibility Resources and Services, at 973-596-2994 or via email at marsha.williamsnicholas@njit.edu. The office is located in Kupfrian Hall, Room 201. A Letter of Accommodation Eligibility from the Office of Accessibility Resources Services office authorizing your accommodations will be required.

For further information regarding self-identification, the submission of medical documentation and additional support services provided, e-mail OARS at OARS@NJIT.EDU, or please visit the Accessibility Resources and Services (OARS) website at:

- http://www5.njit.edu/studentsuccess/disability-support -services/

Chem 702 emphasizes top-ranked professional skills that students need to succeed, such as Collaborative teamwork, Critical thinking, Interpersonal communication, and Trans-disciplinary thinking.

Group Discussion:

The purpose of a **Group Literature Discussion** is to examine carefully and sometimes evaluate a research work or an aspect of a research work of literature. This provides a way for students to engage in critical thinking and reflection as they read, discuss, and respond to research literature. Collaboration is at the heart of this approach. Students reshape and add to their understanding as they construct meaning with other readers. The instructor will assign a literature paper prior to the class meeting, and this will be discussed in a group setting in class. Students are also free to suggest any topic or paper that they would like to be used during the class group Discussion. Students should submit their contributions to the group discussion for grading at the end of each Group Session.

Class Participation

Class participation includes, but is not limited to, class engagement, attendance, and response to questions during class (up to 20 points). This is a discussion-driven and student-centered class. They are expected to be actively involved in discussions and other class activities that would generate the robust energy needed for a successful conversation. Active participation includes completing assignments on time and being present for impromptu class discussions and quizzes. Students who record four or more unexcused absences will receive no points for

class participation. It is strongly advised that a student must use all means available to contact the instructor if he/she must be excused from class in an emergency. When a class is missed, it will be his/her responsibility to find out what was discussed.

Term Paper and presentation:
You will select a specific Green Chemistry Principle, choose a related topic to that principle, research the issues involved, and propose a sustainability approach for solving the chosen problem**.** The length of the term paper or proposal should be at least 5 pages. The report will include:

- Objective of the work
- Background/Literature Review
- Approach, including the Green Chemistry principle chosen
- Chemical basis of the method (instrumental and mechanistic)
- Chemical/Engineering Redesign, optimization and validation validation
- Circular economy encountered
- Possible problems that may be encountered
- How to address these problems

The term paper must be formatted according to the 6th Ed. American Psychological Association(APA) format. 6th Edition APA Style Format can be found at: http://owl.english.purdue.edu/owl/resource/560/02/.

COURSE CONTENTS

Lecture	Topic
Jan 22	**Introduction to Green Chemistry Principles and Sustainability** Role of Green Chemistry for Sustainable Development, SDGs (Baseline Survey)
Jan 29	**Waste Production and Disposal Issues** Environmental Health and Safety Issues and Why We Need Green Chemistry 12 Principles of Green Chemistry (Quiz 1) **(Group Discussion)**

Jan 5	**Metrics: How do we know its Green?** Reaction yield (theoretical, actual, and percentage yield) E-Factor, Atom Economy, Effective mass yield, LCA, RME, Mass Intensity, Problem Solving Mass Productivity, SEEG questions (**Group Discussion**)	
Feb 12	**Designing Green Synthesis -1** VOC issues, Solvent selection guide, solvent-free processes, solvents obtained from renewable resources (Quiz 2)	
Feb 19	**Designing Green Synthesis - 2** Material selection: Solvents, Catalysts, Reagents and Strategies, Processes, Safer-by Design **Group Discussion)** (Working with and without solvents):	
Feb 26	**Social Dimensions of Green Chemistry Social Perspectives** (Dr. Maurie Cohen) **Green Solvents** Ionic Liquids, Supercritical fluids, Fluorous Biphasic Solvents, and other solvents Comparing the Greenness of Solvents (Quiz 3 and Review) Survey 2	
Mar 5	Sustainable Chemistry and Engineering (Guest Speaker) **Energy Requirements for Reactions** Energy efficiency: Using alternative sources of energy: photochemical energy, microwave irradiation, and ultrasonic energy (Mid-Term I)	
Mar 12	**Toxicology**: Introduction, Chemical Dosage, and Exposure (Guest Speaker) **(Group Discussion)**	
	Spring break (March 16-22, 2025)	
Mar 26	**Catalysis and Green Chemistry** Green Catalysis (Enzymes), Photocatalysis, Sonocatalysis, Real-time monitoring with analytical methods **(Quiz 4)**	
Apr 2	**Electrochemical Synthesis** Designing Future Products with Reduced Toxicity: Industrial Case Studies (Videos and Group Discussions)	
Apr 9	**Economic Perspective** (Guest Speaker) (**Quiz 5 and Review)** DYO: Applying Green Chemistry and Sustainability Principles to your research EPA Presidential Green Chemistry Challenge Awards	
Apr 16	Emerging Greener Technologies Nano, Bioplastics, Biopolymers, and Evaluating Technologies (Exam II)	

Apr 23		
	<u>Biotechnology-enabled remediation</u> (Guest Speaker) **Group Discussion** Bringing it all together, Is sustainability possible (Term Paper Due)	
Apr 30	Selected Class Presentations on Term Paper Topics (Final Survey)	
May 7-18	Reading Days and Final Exam Week (Final Exam May 7th)	

Recommended Text

- Green Chemistry: An Introduction Text, 2nd Edition, Mike Lancaster, 344 pages, published by the Royal Society of Chemistry, 978-1-84755-873-2
- Journal articles: The Instructor will provide some journal articles on CANVAS and related topics.

****** Tentative Schedule******