Green Chemistry
The University of Toledo
Department of Chemistry and Biochemistry
College of Natural Science and Mathematics
CHEM 8200, CRN 47313, Section 001

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Office Hours: T, Th 3:00-5:00 pm
Office Location: 3260 Wolfe Hall
Instructor Phone: 419-530-1532

Offered: Fall 2019
Class Location: 2059 Bowman-Oddy Labs
Class Day/Time: Tuesday, Thursday 5:30 – 6:50 pm
Credit Hours: 3

CATALOG/COURSE DESCRIPTION
Advanced topics in green chemistry, including industrial applications, atom economy, safer solvent substitutions, alternatives assessment, green metrics (PMI, E-factor), basic life cycle analysis, and an introduction to chemical toxicology.

COURSE OVERVIEW
Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products, including fuels, plastics, polymers, synthetic fibers, pharmaceuticals, food additives, fragrances, pesticides, herbicides, detergents and cleaning supplies. This course will introduce the principles and fundamental concepts of green chemistry, and provide examples of commercial applications of green chemistry. The course will be especially pertinent for students studying chemistry, medicinal chemistry, chemical engineering, and environmental sciences.

STUDENT LEARNING OUTCOMES
Upon completion of this course, students will be able to:
1. Apply the principles of green chemistry to chemical-related problems and waste reduction.
2. Apply the principles of green chemistry to improve chemical manufacturing processes.
4. Analyze toxicology data, materials properties, and regulatory requirements to choose safer chemicals for product formulations and process chemistry.
5. Understand the fundamentals of chemical alternatives assessment using QCAT and Green Screen.
6. Search authoritative lists for data required to perform a chemical alternatives assessment using QCAT.
7. Utilize EPA software packages to predict physical, chemical, and toxicological properties of chemical substances.
TEACHING METHODOLOGY
Course material will be presented in a traditional lecture style using Power Point slides. The slides will be posted on Blackboard for your convenience. Since I am teaching a distance learning version of this course, those lecture modules will be accessible to you to supplement my in-class lectures. These are not a substitute for attending lectures. Students should keep up with assigned reading and ask questions in class or by email.

PREREQUISITES AND COREQUISITES
Organic Chemistry II (CHEM 2420) or admission into a doctoral program in chemistry or chemical engineering.

REQUIRED INSTRUCTIONAL MATERIALS (TEXTS AND ANCILLARY MATERIALS)
Course material will be taken from the text by Lancaster, supplemented with material from texts by Anastas and Warner, Baird and Cann, and Manahan. Additional examples will be taken from scientific articles and reviews which will be posted as pdf files on the Blackboard site for this course.

Recommended Textbook

Supplementary Texts


Blackboard
Lecture slides, occasional handouts, problem and exam keys, and pdf versions of pertinent scientific articles and reviews will be posted on the Blackboard site for this course. You can login to Blackboard using your UTAD credentials at https://blackboard.utdl.edu/webapps/login/. Your course grade book is also located on Blackboard.

UNIVERSITY POLICIES
Policy Statement on Non-Discrimination on the basis of Disability (ADA):
The University is an equal opportunity educational institution. Please read The University’s Policy Statement on Nondiscrimination on the Basis of Disability Americans with Disability Act Compliance.

ACADEMIC ACCOMMODATIONS
The University of Toledo is committed to providing equal access to education for all students. If you have a documented disability or you believe you have a disability and would like information regarding academic accommodations/adjustments in this course please contact the Student Disability Services Office.
ACADEMIC POLICIES

Academic Dishonesty: The University Policy on Academic Dishonesty will be strictly enforced. See: http://www.utoledo.edu/dl/students/dishonesty.html.

Drop, Withdrawal and Incomplete Grades
Course drop and withdrawal procedures have been set by the University faculty. Dropped courses do not appear on your transcript. The deadline for dropping a course is September 9. If you are in a course after that date, there will be a grade on your transcript. You may withdraw from the course and receive a grade of W. The deadline for withdrawal is November 1. Grades of W do not affect your GPA. You do not need your instructor’s permission for either process. Note that course registration changes might change your financial aid.

A course grade of Incomplete (I) is given only to those who have completed all but a small percentage of course requirements for an acceptable reason. If you have a serious problem near the end of the course, communicate with me as soon as possible. You will retain all of your previously determined grades.

Copyright Notice
The materials in the course website and presentation slides are only for the use of students enrolled in this course for purposes associated with this course, and may not be retained or further disseminated.

COURSE EXPECTATIONS
Students are expected to attend all lectures, arrive on time, and be prepared to take notes on lecture material and ask questions/discuss reading materials.

OVERVIEW OF COURSE GRADE ASSIGNMENT
Final grades will be based on two exams (100 points each), five quizzes (10 points each), an in-depth project/presentation (50 points), and a comprehensive final exam (150 points). The following final grading scale (out of a possible 450 points) will be applied:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Points</th>
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<tbody>
<tr>
<td>A</td>
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<td>B+</td>
<td>360</td>
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<td>C</td>
<td>295</td>
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<td>C–</td>
<td>280</td>
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<tr>
<td>C+</td>
<td>310</td>
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<td>D</td>
<td>250</td>
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<td>D+</td>
<td>265</td>
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Exam and quiz dates are provided below:

- **Exam 1**: Tuesday, October 1
- **Exam 2**: Tuesday, November 12
- **Final Exam**: Tuesday, December 10, 5:00-7:00 pm
- **Quizzes**:
  - Tuesday, September 10
  - Tuesday, September 24
  - Tuesday, October 22
  - Tuesday, November 5
  - Tuesday, December 3

Midterm grades will be assigned based on student performance on the first exam and the first two quizzes.
**Homework:**  Problem sets will be distributed periodically. These will not be collected or graded. Answer keys will be discussed in class and posted online.

**COURSE SCHEDULE**

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topics</th>
<th>Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>August 27 &amp; 29</td>
<td>Introduction, Atom Economy, Principles of Green Chemistry</td>
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<tr>
<td>2</td>
<td>September 3 &amp; 5</td>
<td>Alternative Solvents/Energy Efficiency</td>
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<td>3</td>
<td>September 10 &amp; 12</td>
<td>Catalysis, Abiotic Depletion of Elements</td>
<td>Quiz 1, Sept. 10</td>
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<td>4</td>
<td>September 17 &amp; 19</td>
<td>Renewable Feedstocks</td>
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<td>5</td>
<td>September 24 &amp; 26</td>
<td>Biodegradation</td>
<td>Quiz 2, Sept. 24</td>
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<td>6</td>
<td>October 1 &amp; 3</td>
<td>Introduction to Toxicology</td>
<td>Exam 1, Oct. 1</td>
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<td>7</td>
<td>October 8</td>
<td>Toxicology, Designing Safer Chemicals</td>
<td><strong>No class Oct. 10.</strong></td>
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<td>8</td>
<td>October 15 &amp; 17</td>
<td>Metrics: E-Factor and PMI</td>
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<td>9</td>
<td>October 22 &amp; 24</td>
<td>Commercial Examples of PMI</td>
<td>Quiz 3, Oct. 22</td>
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<td>Life Cycle Analysis</td>
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<td>10</td>
<td>October 29 &amp; 31</td>
<td>Triple Bottom Line, Supply Chain Issues, Business Considerations</td>
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<td>11</td>
<td>November 5 &amp; 7</td>
<td>Risk vs. Hazard Assessment, Chemical Alternatives Assessment</td>
<td>Quiz 4, Nov. 5</td>
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<td>12</td>
<td>November 12 &amp; 14</td>
<td>Environmental Laws, Policies, Regulations</td>
<td>Exam 2, Nov. 12</td>
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<td>13</td>
<td>November 19 &amp; 21</td>
<td>Inherently Safer Design, Emerging Green Technologies</td>
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<td>14</td>
<td>November 26</td>
<td>Presidential Green Chemistry Award Winners</td>
<td><strong>No class Nov. 28</strong></td>
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<td>15</td>
<td>December 3 &amp; 5</td>
<td>Graduate Student Presentations</td>
<td>Quiz 5, Dec. 3</td>
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<tr>
<td>16</td>
<td>December 10</td>
<td>Final Exam, 5:00 – 7:00 pm</td>
<td>Cumulative</td>
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