Chemistry of Sustainable Energy Resources
The University of Toledo
Department of Chemistry and Biochemistry
College Natural Science and Mathematics
(CHEM 3810) (CRN 61892)

Instructor: Dean M. Giolando
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Office Hours: MTWRF 10:00 to 11:00 am
Office Location: WO 2271
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Term: Fall 2016

Class Location: BO 1053
Class Day/Time: MWF 2:00 to 2:50 pm
Credit Hours: 3

COURSE/CATALOG DESCRIPTION
Application of the principles of chemistry to understand the issues related to obtaining a sustainable energy future.

STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Source of Outcome</th>
<th>How Student Achievement of this Outcome Measured</th>
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</thead>
<tbody>
<tr>
<td>1. Communicate effectively</td>
<td>OTM guidelines</td>
<td>Assignments require a hand written free response by the students. Also participation-oral assignments are graded throughout the semester. Assessed by instructor of record.</td>
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<tr>
<td>2. Evaluate arguments in a logical fashion</td>
<td>OTM guidelines</td>
<td>Questions on problem sets and examinations require interpretation of data. Assessed by instructor of record.</td>
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<tr>
<td>3. Employ the methods of inquiry</td>
<td>OTM guidelines</td>
<td>Material contained in the course material require students to analyze data relevant to other disciplines. Assessed by the instructor of record.</td>
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<tr>
<td>4. Acquire an understanding of our global society</td>
<td>OTM guidelines</td>
<td>Students are given projects and assignments wherein the course content is placed in a broader context of human interactions with the planet. Assessed by the instructor of record.</td>
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<tr>
<td>5. Engage in our democratic society</td>
<td>OTM guidelines</td>
<td>Course content is provided on topics relevant to today’s society so they will be better informed citizens. Assessed by the instructor of record.</td>
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TEACHING STRATEGIES
An examination on the course content will be given on the first day to assess the knowledge base of the students on entering the course. This will identify topics for which the students are familiar, which may require only passing review in lecture, and those topics for which the student is lacking in knowledge and experience. Course lectures are modified to maximize student learning of new information.

A project-based approach is used wherein face-to-face lectures begin with a lead-in question, followed by thought experiments addressing the question – with student engaged in oral responses – and finishing with incorporation of new information from the textbook and other sources to give insights into the chemical nature of materials.

Students are broken into groups of 4 to 5 who research topics during class time, they then present their findings to the class as a whole.

PREREQUISITES AND COREQUISITES
General Chemistry I (CHEM 1230), General Chemistry I Laboratory (CHEM 1280), Physical Principles of Energy Sources for Humans (PHYS 3400). These can be waived by the instructor.

REQUIRED TEXTS AND ANCILLARY MATERIALS
There are no standard textbooks available for this course. Source material will be taken from a variety of sources and adapted to stay current with the changing needs of the world energy situation. Some relevant sources, though not exhaustive, are listed below.

1. The Energy Information Administration of the US Department of Energy has a vast store of data online at: eia.doe.gov/.
2. The US Geological Survey also conducts periodic analysis of the fossil fuel resources globally. These can be found at: usgs.gov/.
3. The International Atomic Energy Agency keeps data on nuclear energy: www.iaea.org/.

Books made available to the students:
Greenwood and Earnshaw, Chemistry of the Elements, Reed, 1998.

TECHNOLOGY REQUIREMENTS
Laptop or smart phone to access the web during class.

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: You are urged to refer to the university’s policy on Academic Dishonesty in the university catalogue. Violation of this policy can result in a course grade of F with additional university sanctions possible.

Students who will not be able to take an exam at the scheduled time due to an irresolvable conflict with a major responsibility must provide some written documentation to verify the conflict. This situation may occur for students on official university business. The exam will be given at another arranged time before the scheduled test date.

Students who miss an exam due to illness, car accident or similar extreme circumstance should inform their instructor of their difficulties as soon as possible. These difficulties must also be documented by a physician’s note, an accident report, etc. An email to your instructor and a telephone call within 24 hours is expected. Students must complete an Absence Report Form (obtained from the chemistry office, BO 2022). Documentation supporting your excuse must be attached to the form. In all other circumstances a missed exam will result in a grade of zero points.

(Insert specific academic policies the student is expected to comply with; policies may include student conduct, academic dishonesty, missed class policy, student grievances, etc.)

COURSE EXPECTATIONS
(Insert a clear explanation of any and all course expectations you have. For example, parameters on class start times (tardiness); are late assignments accepted and if so under what circumstances, will late assignments be given full credit, is there extra credit, participation and attendance expectations, etc.)

GRADING
1. In-class closed book Examinations (100 points each): totals 300 points; given on Friday 9/30/16, 10/28/16, 12/02/16.

2. Assignments (20 points each): totals 100 points;

homework assignments covering concepts, issues, and ideas related to a lecture topic and to be completed at the end of the day of 9/9/16, 9/23/15, 10/14/16, 11/11/16 and 12/09/16 during the 15 week term; Students are encouraged to work together, but assignments turned in that are copies of one another will share the grade.

3. Term Project (100 points): capstone project where students assess the impact of chemistry to a specific energy source. Chose an energy topic from the list provided and determine what it takes to bring the energy source to society. The project is presented to the class with the objective of teaching your friends and peers the most important aspects of your topic.

Abstract (circa 100 words): due 10/07/16
Papers (circa 5 to 10+ pages): due 11/18/16
Presentations (circa 10 minutes): 5 per day, need 5 days,
1. Ores and minerals; delivering pure elemental product;
2. Desalination; delivering pure drinking water;
3. Nitrogen fertilizer from dinitrogen; delivering food;
4. Phosphorous fertilizer from ores; delivering food;
5. Sequestering nutrients from farm run-off;
6. Gasoline from oil; delivering a liquid fuel;
7. Diesel from synthesis gas (CO/H₂) (Fischer-Tropsh);
8. Natural gas as a fuel;
9. Methane reforming;
10. Alcohols as a fuel;
11. Lipids as a fuel;
12. Oil as a fuel;
13. Coal as a fuel;
14. Si based photovoltaics;
15. CdTe based photovoltaics;
16. Solar thermal, large-scale electricity;
17. Solar Thermal, residential-scale hot water;
18. Ocean power;
19. Wind power;
20. Geothermal;
21. Use of microbes/algae/yeasts;
22. Nuclear Power;
23. Hydroelectric;

4. Final Examination (200 points): comprehensive final examination; Thursday 12/15/16 at 12:30 - 2:30 pm.

5. Participation during class (50 points). Bring your laptop computer or Smart Phone to class for searching topics.

Final Grading
A, 100-90; B, 89-80; C, 79-70; D, 69-60; F, <59%.

COURSE SCHEDULE
Topics for CHEM-3810-001 “Chemistry of Sustainable Energy Resources”

Weeks 1 and 2

1. Where does it all come from? (Chemistry of the Elements)
   Origin of the elements
   Abundance of the elements in the universe and Earth’s crust
   Binding of electron to the nucleus
   Building the Periodic Table
   Formation of covalent bonds

Week 3

2. Chemistry Behind Recycling and Reuse
   Common minerals (Chemistry of the Elements)
   Production of silicon and aluminum metals
   Aluminum recycling
   Metal recycling (McGraw-Hill: Handbook of Recycling)
   Plastics recycling
Weeks 4 and 5

3. **Carbon, Hydrogen and Oxygen Bonds**
   - Water, carbon and nitrogen cycles (Chemistry of the Elements)
   - Desalination of sea water
   - Organic chemistry found on the Earth’s crust (Organic Chemistry text)
   - Natural polymers in nature

Weeks 6 and 7

4. **Advantage and Disadvantages of Biomass and Fossil Fuels**
   - Bio –molecules, organic compounds in living systems
   - Precursors to fossil fuels
   - Breaking down the organic material to bio-fuels
   - Use of algae systems

Weeks 7 and 8

5. **Fuels of Today and into the Future**
   - Gasoline from oil
   - Diesel from Syn gas (CO/H₂): Fischer Tropsh process
   - Preparation of CO from carbon sources
   - Methane, propane and butane; Ethanol and butanol
   - Energy content of carbon based fuels: sticks to coal

Week 9

6. **Nature’s Sources of Energy**
   - Photosynthesis
   - Hydrogenases
   - Methane from microbes
     - On the farm and in the landfill

Week 10

7. **Hydrogen as a fuel**
   - Production of H₂ from coal, methane or water
   - Uses of hydrogen in fuel cells
     - Overview of the different types of fuel cells

Weeks 11 and 12

8. **Solar Photovoltaics**
   - How solar cells generate electricity
   - Si: Crystalline and amorphous
   - CdTe
   - CuInSe₂

Week 13

9. **Solar Photovoltaics**
   - TiO₂ based
   - Earth Abundant
   - Nano technology
   - Organic
Week 14

10. Solar Thermal
   How to make use of the thermal heating
   Materials needed for
   Hot water heaters
   The Hawaiian Electric Power Utility model
   Generation of electricity

11. Nuclear
   Sources of fuel, Refinement of ores
   Reclamation of spent fuels
   Advantages/Disadvantages

Week 14 and 15

Term project Presentations

For Honors Section (091) an addition paper is due 12/9/2016.

Students will independently research a topic in chemistry related to sustainability, prepare a one-page abstract, and a ten page paper on the subject. The abstract must include a minimum of 10 key references cited in the text. References must be listed using standard ACS format as found in the ACS Style Guide and in the January 2016 issue of Journal of the American Chemical Society. The abstract should be single-spaced, with 1" margins, and in Times or Times New Roman size 12 font. In the paper, students must define the topic, provide pertinent background and examples and explain the relevance to society. Details to present may include synthetic schemes, bonding descriptions, mechanistic details, and commercial significance. The presenter must be prepared to answer questions from the instructor of the course.

Topics could include, but are not limited to, the following:

- Water shift reaction
- Fischer Tropsch
- C–H Bond Activation
- Chemical Vapor Deposition
- Hydroformylation
- Nanotechnology
- Hydrogenases
- Nitrogenase
- Methane reforming
- Shell Higher Olefins Process
- Zeolites
- Renewable Energy