

CHEMISTRY 401: CHEMISTRY and BIOCHEMISTRY SEMINAR
section 05 Hydrogen Energy Systems
Spring 2013 Course Syllabus

The quest for artificial photosynthesis has been called one of the “holy grails” of chemistry. During the past four centuries, scientists have unraveled the secrets of the leaf in order to understand how natural photosynthesis uses solar energy to make carbohydrate fuels. For the past four decades, chemists have struggled to reinvent the leaf by developing synthetic molecular systems that use solar energy to split water and produce hydrogen fuel. While the progress has been frustratingly slow, the pressing need to develop a clean and carbon-free solar fuel has re-ignited artificial photosynthesis research and has led to major breakthroughs in recent years. Is there hope to move beyond fossil fuels and power the planet with a synthetic leaf?

I. SCHEDULE OF DISCUSSION TOPICS

(TENTATIVE — see course Moodle page for up-to-date schedule)

date	Topic	
Tues. Jan. 15	1. Solar Fuels: Why, What, How	a. Energy Challenges
Thurs. Jan. 17	1. Solar Fuels: Why, What, How	b. Solar Energy Solutions
Tues. Jan. 22	2. Hydrogen Energy Systems	a. Hydrogen Production
Thurs. Jan. 24	3. Natural and Artificial Photosynthesis	a. Photosynthesis
Tues. Jan. 29	3. Natural and Artificial Photosynthesis	b. The Water-splitting Reaction
Thurs. Jan. 31	4. Light Harvesting	a. Absorption and Excited States
Tues. Feb. 5	4. Light Harvesting	b. Energy Transfer
Thurs. Feb. 7	5. Charge Separation	a. Photo-induced Electron Transfer
Tues. Feb. 12	5. Charge Separation	b. Multi-component Electron Transfer
Thurs. Feb. 14	6. Hydrogen Evolution Catalysts	a. Proton Reduction Half Reaction
Tues. Feb. 19	6. Hydrogen Evolution Catalysts	b. Design of H ₂ -Evolution Catalysts
Thurs. Feb. 21	7. Water Oxidation Catalysts	a. Water Oxidation Half Reaction
Tues. Feb. 26	7. Water Oxidation Catalysts	b. Design of Water Oxidation Catalysts
Thurs. Feb. 27	<i>review</i>	
Spring Break		
Tues. Mar. 19	Mid-term Exam	
Thurs. Mar. 21	8. Photoelectrochemical Cells	
Tues. Mar. 26	8. Photoelectrochemical Cells	
Thurs. Mar. 28	9. Semiconductor Nanoparticle Photocatalysts	
Tues. Apr. 2	9. Semiconductor Nanoparticle Photocatalysts	
Thurs. Apr. 4	10. Molecular Photocatalysts	
Tues. Apr. 9	<i>no class</i>	
Thurs. Apr. 11	10. Molecular Photocatalysts	
Tues. Apr. 16	11. Photobiological Hydrogen Production	
Thurs. Apr. 18	11. Photobiological Hydrogen Production	
Tues. Apr. 23	12. Building an Artificial Leaf	a. Synthesis, structure, and self-assembly
Thurs. Apr. 25	12. Building an Artificial Leaf	b. Earth-abundant elements
Tues. Apr. 30	13. Operating an Artificial Leaf	a. Operating efficiency
Thurs. May 2	13. Operating an Artificial Leaf	b. Stability and Self-repair
Thurs. May 9	Final Paper due at 8:30 am	

II. CLASS MEETING TIMES:

Chemistry 401 meets in Tomsich Hall 206 during period B (T, R 9:40–11 AM).

III. INSTRUCTOR:

Prof. Scott D. Cummings

Phone: PBX 5355

E-mail: cummings@kenyon.edu

Office: Tomsich Hall 314

Office Hours: *TBA*

My schedule is posted on my office door and at: <http://chemistry.kenyon.edu/cummings/schedule.htm>

IV. COURSE REQUIREMENTS**A. PRE-REQUISITES:**

The material covered in *Introductory Chemistry* (CHEM 121–126) is a prerequisite for this course, and some of the material will complement the content in *Chemical Kinetics & Thermodynamics* (CHEM 335). Textbooks from these courses may be helpful reference materials.

B. ATTENDANCE REQUIREMENTS:

Participation during class is an essential part of this course and students are expected to attend all classes. Excessive absences will lead to a lower grade and may lead to expulsion from the course. Only excused absences from a college dean are recognized as a valid reason for missing class. In the event of an absence from class, the student is responsible for securing any notes, handouts or announcements from the class. I call your attention to the college policy on class attendance in the *Course of Study*:

“Absences for reasons of illness are not ordinarily excused: only when a student is declared by the College physician to be infirm (in a hospital or at home) will a health report be sent from the Health and Counseling Center to the dean of students, giving the days when each patient is judged infirm and recommending that the student’s class absences be excused.”

Student-Athletes: I call your attention to the college policy on class attendance in the *Scheduling Guidelines for Athletic Contests* (<http://www.kenyon.edu/PreBuilt/provCASatleticsgl.doc>). All potential athletic conflicts should be identified for the professor by the end of the first week of classes each semester and cannot exceed 10% of our semester meeting times. If your absence is not excused, you will not be allowed to make the work up.

Because of the room arrangement and capacity, please be on time to class.

C. REQUIRED MATERIALS:

- all readings will be provided; please bring them to class in electronic or print format.
- a basic scientific calculator — *bring it to every class*.

Important course materials (schedule, Study Guides, videos, some ancillary class materials, and exam information) are available on our course Moodle Site at <http://moodle.kenyon.edu> (log in and select CHEM 401). Some class announcements may be made by e-mail to your Kenyon account.

IV. ASSIGNMENTS and ASSESSMENT

A. HOMEWORK

For each topic, you will be provided with a Study Guide that lists the weekly reading assignments and discussion questions. Because this is a seminar, students are expected to come to class prepared for discussion of readings and/or assigned problems. During class, we will discuss answers to some of the questions; some of those remaining may be assigned as homework problems and collected for a grade. Discussion questions are the basis of the mid-term exam.

B. PRESENTATIONS

During the semester, students will develop three oral presentations on various aspects of artificial photosynthesis and present them in class.

- For Topics 3–5*, each student will be assigned one topic to present in class as a short (~10 min.) mini-lecture.
- For Topics 6–7*, each student will present in class a short (~15 min.) mini-lecture on research literature addressing water-oxidation or proton-reduction catalysts.
- For Topics 8–11*, each student will select one method of photochemical water splitting and present a 20-min. review in class; this method also will be the topic of your term paper.

C. EXAMINATION

A mid-term exam that covers Topics 1–7 will be offered in class on **Tuesday, March 19**. *Please note this date and time and do not plan travel; no alternate exam times can be offered.*

Quizzes (possibly unannounced) *may* be given, if class discussion is lacking. An unexcused absence from lecture does not allow for a make-up quiz.

D. TERM PAPER

Each student will write a research paper discussing examples from the primary research literature on one method of photochemical water splitting. Format and guidelines will be discussed in class. The paper is due in electronic format on **Thursday, May 9 at 8:30 am** (As scheduled by the Registrar for the course final exam time); *there is no final exam*.

E. GRADING POLICIES

This class is *NOT* graded “on a curve” so you are encouraged to work with other students in your studies. You are not competing against each other for a grade. Instead, all work is graded based on absolute criteria:

- A = superior mastery of concepts; creative work; exceptional effort
- B = sound approach; demonstrated understanding of fundamental concepts; solid effort
- C = misunderstanding of some key concept; some effort
- D = inability to solve problem; not enough effort
- F = didn't try

Your final grade will be determined by the following weighting:

PRESENTATIONS:	20%
MID-TERM EXAM:	20%
TERM PAPER:	40%
HOMEWORK & CLASS PARTICIPATION:	20%

V. COLLEGE POLICIES:

A. ACADEMIC STANDARDS AND HONESTY

I call to your attention the College policy on Maintenance of Academic Standards and Academic Honesty in the *Course of Study*. I am required to send progress reports for students performing below a grade level of C. I run this and all my courses with the assumption of complete academic honesty by all students.

Referencing your sources and using your own original voice in your writing is an essential part of academic honesty. Please be sure you are very clear about documenting the sources you use on work you present or submit for a grade.

B. STUDENTS WITH DISABILITIES

If you have a physical, psychological, medical or learning disability that may impact your ability to carry out assigned course work, I urge you to contact the Office of Disability Services. The Coordinator of Disability Services, Erin Salva (salvae@kenyon.edu; X5453), will review your concerns and determine with you what accommodations are appropriate. ONLY the Coordinator of Disability Services can make accommodations, but please feel free to discuss your concerns in private with me. All information and documentation of disability is confidential.