MSE 598 Special Topics: Electrochemical Energy Storage and Conversion
(Crosslisted as: MSE 494, CHE 494, CHE 598, NAN 598, MAE 598)

Course Syllabus
Instructor: Prof. Candace Chan
(Tel: 480-727-8614, email: candace.chan@asu.edu)
Office hours: Tuesday 4:30-5:30 pm or by appointment, ISTB4 381

Semester: Fall 2013
Meeting Day, Time and Place: Tues/Thurs, 12-1:15 pm, PABLO 101

Course Description
This course will introduce electrochemical concepts relevant to real-world devices such as electrochemical energy storage devices, photoelectrochemical energy conversion devices, and solid-state electrochemical devices such as sensors. Basic electrochemical principles with an emphasis on solid state electrochemistry and the nature of the solid-electrolyte interface will be discussed, in order to give students the background knowledge needed for understanding and analyzing real device performance of, e.g. lithium-ion batteries, solar hydrogen generation, electrocatalysts, electrochemical capacitors, etc. By the end of the course, students will be able to critically evaluate media reports and journal publications describing electrochemical energy conversion and storage devices.

Prerequisites: Undergraduate-level general chemistry (e.g. CHM 114, 116) and intro physics (e.g. PHYS 121-131); intro materials science (e.g. MSE 250) and thermodynamics (e.g. MSE 330) highly recommended. For graduate students and advanced undergraduates in engineering and physical science disciplines.

Textbooks: There is no single textbook available that covers the breadth of subjects that will be discussed in this class. Lecture material will be taken from various books and publications, all of which can be obtained online as ebooks using the ASU library license.


Other sources:
Solid State Electrochemistry, Bruce
Electrochemical Methods, Bard & Faulkner
Semiconductor electrodes and photoelectrochemistry, Licht
The CRC Handbook of Solid State Electrochemistry, Gellings & Bouwmeester

Course Content Changes
Course content may vary from this outline to meet the needs of this particular group. Dates for class tests may also be shifted.

Homework
Development of problem solving, critical thinking and analytical skills is a critical component of this course content. Graded problem sets will be assigned for practice in problem solving techniques and capacity for critically analyzing electrochemical data. Active participation in attempting these problems is essential for success in this course. Unless you work attentively and persistently on these problems
you will not achieve the course objectives. Students who fall substantially behind on these problems are unlikely to perform well on the tests. Students are encouraged to have “study buddies” and may work together on homeworks in groups, but each student must turn in their own work. Homework assignments that are duplicated, plagiarized, or violate ASU’s Academic Integrity Policies (https://provost.asu.edu/academicintegrity) will be reported as per University policy.

**Attendance Policy**
Attendance in this class is important and is strongly encouraged.

**Disability Policy**
The university will make reasonable accommodations for persons with documented disabilities. Students should notify Prof. Chan of any special needs.

**Course Grading**
1. Homework will count for 20% of the final grade. Homeworks are generally assigned on Thurs. and due the following Thurs. at the beginning of class. Late homework will not be accepted.

2. One midterm test worth 25% of the final grade is tentatively scheduled for Oct. 10 in class. Makeup tests will not be available unless Prof. Chan is notified well in advance and/or the absence is due to an excusable reason (e.g. medical/family/other emergency).

3. A final comprehensive exam worth 25% of the final grade will be held during the final exam period of Dec. 9 – 14 (corrected). The final exam date and time are scheduled by ASU and will be announced later during the semester. Makeup tests will not be available unless Prof. Chan is notified well in advance and/or the absence is due to an excusable reason (e.g. medical/family/other emergency).

4. A final presentation worth 20% of the final grade will be required for graduate students. This assignment will be a conference-style oral presentation on a journal publication of the student’s choice (provided it is related to the course material). The goal of this assignment is for students to practice their critical thinking and apply course concepts towards understanding real-life examples, while also developing oral presentation skills. Undergraduate students will write a final paper instead of a final presentation. Details of these assignments are attached.

5. Course participation worth 10% of the final grade will involve filling out surveys to enable Prof. Chan to assess student engagement and understanding, as well as content delivery. The survey must be done after each lecture by 11:59 pm the same day of the class. This is described in more detail under the section on Concept Warehouse.

**Grading basis:**
- Homework: 20%
- Midterm: 25%
- Final exam: 25%
- Final presentation/paper: 20%
- Course participation: 10%

Plus/minus grading will be used.
Regrades of homeworks and exams will only be conducted if the student turns in a written explanation of why they think an error was made in the grading, along with the original work, to Prof. Chan within one week of the time the graded work was returned to the student.

**Extra Credit**
There are no separate extra credit assignments for this class. The schedule of assignments and exams are sufficient to test your understanding of the materials presented in the course. However, occasionally there will be opportunities for extra credit in the homework problems.

**Blackboard**
I will use Blackboard to post lecture notes, homework, grades and other resources that may help you. To access Blackboard use the following:

1. Go to Blackboard: [http://myasucourses.asu.edu](http://myasucourses.asu.edu)
2. Under My Courses, select MSE 598 Topic: Electrochemical Energy Storage
3. On left-hand panel, select Course Information
4. For lecture notes go to Lectures folder, for homework go to Homework folder etc...

**Concept Warehouse**
I will use Concept Warehouse for assessing the “muddiest” (e.g. unclear or confusing points) and most interesting points for each lecture. This will serve to help identify difficult concepts and misconceptions and will allow me to address these well before the exams. Each student will be responsible for filling out the muddiest/interesting point survey at the end of each lecture. While the feedback will remain anonymous, I can track your participation. Students are allowed to miss one survey without penalty. Student participation in 20 surveys or more will result in a 100% for the course participation grade. The course participation grade will scale proportionally with the number of surveys completed. For example, 10 completed surveys will result in $10/20 = 50\%$ for the course participation grade. Students who must miss class due to prior commitments or excused absences can still complete the surveys using the lecture slides. To access Concept Warehouse use the following:

1. Create a student account using your ASU email address. Prof. Chan has already added you to her Concept Warehouse MSE598 class so you must use the same email address.
   Follow the instructions here: [http://jimi.cbee.oregonstate.edu/concept_warehouse/student_login.pdf](http://jimi.cbee.oregonstate.edu/concept_warehouse/student_login.pdf)
2. Go back to the login and sign in: [www.cw.edufiv.org](http://www.cw.edufiv.org) (or google “AIChE Concept Warehouse”)

**Course Schedule (subject to change)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture</th>
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<tbody>
<tr>
<td>Thurs 8/22</td>
<td>Lecture 1: Course intro</td>
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<tr>
<td>Tues 8/27</td>
<td>Lecture 2: Introduction to electrochemical concepts</td>
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<tr>
<td>Thurs 8/29</td>
<td>Lecture 3: The double layer and supercapacitors</td>
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<tr>
<td>Tues 9/3</td>
<td>Lecture 4: Potentials and thermodynamics part 1</td>
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<tr>
<td>Thurs 9/5</td>
<td>Lecture 5: Potentials and thermodynamics part 2</td>
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<tr>
<td>Tues 9/10</td>
<td>Lecture 6: Electrode kinetics part 1</td>
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<tr>
<td>Thurs 9/12</td>
<td>Lecture 7: Electrode kinetics part 2</td>
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<tr>
<td>Tues 9/17</td>
<td>Lecture 8: Electrolysis</td>
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<td>Thurs 9/19</td>
<td>Lecture 9: Photoelectrochemistry part 1</td>
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<td>Tues 9/24</td>
<td>Lecture 10: Photoelectrochemistry part 2</td>
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<td>Date</td>
<td>Lecture Topic</td>
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<td>Thurs 9/26</td>
<td>Lecture 11: Photoelectrochemistry part 3</td>
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<td>Tues 10/1</td>
<td>Lecture 12: Photoelectrochemistry part 4</td>
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<tr>
<td>Thurs 10/3</td>
<td>Lecture 13: Intro to solid state electrochemistry</td>
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<td>Tues 10/8</td>
<td>Lecture 14: Mixed conductors/electrochemical memory</td>
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<tr>
<td>Thurs 10/10</td>
<td><strong>Midterm</strong></td>
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<tr>
<td>Tues 10/15</td>
<td>Fall break, no class</td>
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<td>Thurs 10/17</td>
<td>Lecture 15: Lithium batteries part 1</td>
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<td>Tues 10/22</td>
<td>Lecture 16: Lithium batteries part 2</td>
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<tr>
<td>Thurs 10/25</td>
<td>Lecture 17: Lithium batteries part 3</td>
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<tr>
<td>Tues 10/29</td>
<td>Lecture 18: Lithium batteries part 4</td>
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<tr>
<td>Thurs 10/31</td>
<td>Lecture 19: Fuel cells part 1</td>
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<tr>
<td>Tues 11/5</td>
<td>Lecture 20: Fuel cells part 2</td>
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<td>Thurs 11/7</td>
<td>Lecture 21: Metal air batteries</td>
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<tr>
<td>Tues 11/12</td>
<td>Lecture 22: Grid storage</td>
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<tr>
<td>Thurs 11/14</td>
<td>Presentations 1-4</td>
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<tr>
<td>Tues 11/19</td>
<td>Presentations 5-8</td>
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<td>Thurs 11/21</td>
<td>Presentations 9-12</td>
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<tr>
<td>Tues 11/26</td>
<td>Presentations 13-16</td>
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<tr>
<td>Thurs 11/28</td>
<td>Thanksgiving, no class</td>
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<tr>
<td>Tues 12/3</td>
<td>Presentations 17-21</td>
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<tr>
<td>Thurs 12/5</td>
<td>Last day of class, review for final, Final paper due (for undergraduates)</td>
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**Important dates:**

- 8/28  Last day to drop without college approval
- 10/16 Fall break, no class
- 11/6  Course withdrawal deadline
- 11/28 Thanksgiving, no class
- 12/5  Last day of class
- **12/9-12/14** Finals period (corrected)
- 12/18 Final grades posted
Final Presentation: for M.S. and Ph.D. students (registered under 598)

A final presentation worth 20% of the final grade will be required for graduate students. **Students will work in groups of 2 and will receive the same grade as their partner.** The presentation dates will be on 11/14-12/3. Presentation dates and groups will be assigned by random drawing after the midterm. This assignment will be a conference-style oral presentation on a journal publication of the student’s choice (provided it is related to the course material). The goal of this assignment is for students to practice their critical thinking and apply course concepts towards understanding real-life examples, while also developing oral presentation skills.

1. Choose a publication from one of the journals listed below that discusses a topic that is related to the material covered in the class, or can be explained using electrochemical concepts covered in the class.

   - Journal of the Electrochemical Society
   - Electrochemical and Solid State Letters
   - Journal of Power Sources
   - Electrochimica Acta
   - Advanced Energy Materials
   - Energy and Environmental Science
   - Nano Letters, ACS Nano, Chemistry of Materials
   - Journal of the American Chemical Society
   - Advanced Materials
   - Science
   - *Other journals must be approved by Dr. Chan

2. Check with Dr. Chan on the appropriateness of the publication at least ONE WEEK before your presentation. Email her a copy of the publication for approval.

3. Prepare a 15 minute talk that discusses the following:
   - Background/intro: What is the motivation for this work? What problems/issues does it aim to solve?
   - Methods: What is the approach to solving the problem?
   - Results: What are the relevant results AND their significance?
   - Conclusions: Summarize the findings.
   - Critique and suggestions for future work: Do you have any questions about the methods or results? Anything you would have done differently? If you were working on this project, what would you do next?
   - Allow ~ 5 min for questions from the audience

4. Grading criteria

   The presentations will be graded as followed:

   - 10% Attendance – you need to attend the presentations of your peers. **Content from the presentations may show up on the final exam.**
   - 55% Evaluation from Dr. Chan
   - 35% Evaluation from peers

   Evaluation criteria: On a scale from 1 to 5

   - **Appearance**
     Is your presentation professional looking? Any typos, misspellings, or formatting choices that detract from the overall presentation?

   - **Clarity**
     Was the material presented clearly so that everyone could understand? Were unfamiliar concepts or terms explained well?
Comprehension Did you interpret the publication correctly? Could you answer the audience’s questions?

Preparedness Is it obvious that you prepared and rehearsed the presentation beforehand?

Content Did you include the relevant content to describe the motivation, methods, results, and conclusions?

Delivery Did you time the presentation appropriately?

5. Email Dr. Chan a copy of your presentation to post on Blackboard
Final Paper: for undergraduate students (registered under 494)
Undergraduate students will write a final paper instead of a final presentation. Due date: **Thursday Dec. 5.**

1. Choose a publication from one of the journals listed below that discusses a topic that is related to the material covered in the class, or can be explained using electrochemical concepts covered in the class.

   - *Journal of the Electrochemical Society*
   - *Nano Letters, ACS Nano, Chemistry of Materials*
   - *Electrochemical and Solid State Letters*
   - *Journal of the American Chemical Society*
   - *Journal of Power Sources*
   - *Advanced Materials*
   - *Electrochimica Acta*
   - *Advanced Energy Materials*
   - *Science*
   - *Energy and Environmental Science*

   *Other journals must be approved by Dr. Chan*

2. Check with Dr. Chan on the appropriateness of the publication at least ONE WEEK before the due date.

3. Write a 2 page (at least) review paper about the publication. Format: 1 inch margins, 11 pt Times New Roman or similar, single-space, no spacing between paragraphs. Discuss the following in your paper:
   - Background/intro: What is the motivation for this work? What problems/issues does it aim to solve?
   - Methods: What is the approach to solving the problem?
   - Results: What are the relevant results AND their significance?
   - Conclusions: Summarize the findings.
   - Critique and suggestions for future work: Do you have any questions about the methods or results? Anything you would have done differently? If you were working on this project, what would you do next? *(Need at least one full paragraph devoted to this)*

4. The papers will be graded as followed:

   - **10%** Attendance – you need to attend the presentations of your peers. **Content from the presentations may show up on the final exam.**
   - **90%** Evaluation from Dr. Chan

   Evaluation criteria: On a scale from 1 to 5

   - **Appearance** Is your paper professional looking? Any typos, misspellings, or formatting choices that detract from the overall presentation?
   - **Clarity** Was the material presented clearly so that the reader could understand? Were unfamiliar concepts or terms explained well?
   - **Comprehension** Did you interpret the publication correctly?
   - **Content** Did you include the relevant content to describe the motivation, methods, results and conclusions?
   - **Critique** Did you come up with critical comments and reasonable suggestions for future work?