MSE 301/581 – Materials Chemistry – Fall 2008

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Credits: 3 hours

Catalog Description: Provides a molecular understanding of materials properties: introductory quantum chemistry, basic organic chemistry, non-covalent interactions, electrochemistry, and surfaces and interfaces. Materials addressed include polymers, biopolymers, ceramics and glasses, optical materials, and metallic, semiconductor, and silica nanoparticles.

Class time: MWF 10:10-11:00 in 140 Bard Hall
NO CLASS Wednesday, Oct. 1 (Rosh Hashannah)
Monday, October 13 (Fall Break)
Friday, November 28 (Thanksgiving Break)

Labs: Coordinated two labs with MSE 311

Recommended Prerequisites: Chem 207 OR Chem 211

Text: There is no one text that adequately covers all of the topics that will be addressed in this course. Instead, I have assembled a course packet from 9 different sources. This packet is available from the Cornell Bookstore and is required.

Reserved Books at Engineering Library:
- Intermolecular & Surface Forces Jacob Israelachvili, Academic Press (1992)
- Ceramic Processing and Sintering Rahaman, CRC (2003)
- Chemistry of Glass, Vogel, The American Ceramic Society (1985)

Clickers: I will be experimenting with using “Clickers” in class this year. Thompson has some available for you or you can get them through the bookstore.

Lectures: Lectures are a key component to this course and while I strongly advise attendance at the lectures, it is not mandatory. The lectures will go beyond what is in the text, and students will be responsible for all material presented in lectures. Questions during lecture are strongly encouraged. My lecture notes will be posted on Blackboard after each lecture.
**Homework:** Problem sets will be distributed on Friday at the lecture and due the following Friday at lecture. Late homework assignments (those turned in after 12 Noon on Fridays) will have 10% deducted per day until the answer key is posted, after which they will not receive any credit. There will be a folder outside of Prof. Estroff’s office (Bard 329) for dropping off homework not turned in during class. Many of the problem sets will include questions that require short (~1 paragraph) written responses. I believe that written communication is essential to be successful engineers and scientists.

**Examinations:** There will be three mid-term exams, all given during class time. All exams will be cumulative, with a focus on the more recent material. Your homework assignments will be your best study guides. Last year’s problem sets, exams, and answer keys are also available as study aids on the Blackboard site.

**Tentative Dates:**
- Exam 1 – Tues., Sept. 23 (evening)
- Exam 2 – Tues., Oct. 21 (evening)
- Exam 3 – Tues., Nov. 18 (evening)

Final – set by the University. Period H, Monday, Dec. 15, 9-11:30 AM. Room TBA.

**Grading:**
- Homework (~12): 20%
- Midterm exams: 55%
- Final exam: 25%

**Office Hours:** If I am in my office and the door is open, I am available to talk. When my door is closed I am either not there or busy. I have reserved some “official” hours during which class questions will take precedence. The TAs for the course will also have scheduled office hours. Before exams, there will be both in-class review sessions on the Monday before the exams and I will schedule separate evening or weekend review sessions.

- Prof. Estroff’s Office Hours: Monday: 2:30-4:00 PM
  Tuesday: 10:00-11:30 AM
- Miki Kunitake’s Office Hours: Thursday: 2:00-4:00 PM (Bard Hall Lounge)
- Seth and Chris’ Office Hours: Wednesday: 4:30-6:30 PM (Bard Hall Lounge)

**Blackboard and Email:** There is a Blackboard site for the class. Please register for it in the next two weeks (MSE301/581: Materials Chemistry). All problem sets, solution sets, supplemental materials, and lecture notes will all be posted. Lecture notes will be posted AFTER the lecture has been given. I will respond to emails and if appropriate, forward my responses to the entire class.
Course and Lecture Outline

Weeks 1-3 (Aug. 29 – Sept. 19)

Topic 1: Bonding, Acids and Bases, and Intermolecular Forces
Readings: Part 1; Sections 1.1, 1.2; pg. 5-63
Lewis Dot structures; Acids and Bases; Bonding; electronegativities; dipole moments; intermolecular forces of attraction

Topic 2: Quantum Chemistry - Atomic and Molecular Orbitals
Readings: Part 1; Sections 2.1-2.5; pg. 67-147
Quantum Mechanics; particle-in-a-box; rigid rotor; Hydrogen Atom; H$_2^+$; Variation method for solving diatomic molecules; hybridization; Heterodiatomic; HOMO/LUMOs

Weeks 4-8 (Sept. 24 – Oct. 27)

Topic 3: Quantum Chemistry Applied
Readings: Part 1; Sections 2.6-2.10; pg. 151-229
Conjugation and pi-systems; Hückel Molecular Orbital Theory; Metallic Bonding/semiconductors; Conducting Polymers

Topic 4: Organic Chemistry - Reactions and Polymers
Readings: Part 2; Sections 3.1-3.5; pg. 5-89
Organic Chemistry Introduction; nomenclature; Basic reaction classes; nucleophilic substitutions; Electrophilic additions to alkenes; Carbonyl Chemistry; Polymer Synthesis and retrosynthesis; Polymer Properties; Photoresists

Weeks 9-13 (Oct. 29 – Nov. 26)

Topic 5: Chemistry of Glasses
Readings: Part 2; Sections 4.1, 4.2; pg. 93-137
Introduction to Glasses; glass formation; Synthesis of Glasses (sol-gel); Biosilification

Topic 6: Chemistry of Color
Readings: Part 2; Sections 5.1-5.3; pg. 141-166
Crystal Field Theory; Ligand Field Theory; fluorescence; phosphorescence; absorption; emission; Organic LEDs; quantum dots; plasmon resonance

Topic 7: Electrochemistry and Corrosion
Readings: Part 2; Sections 6.1-6.3; pg. 169-234
Review of Electrochemistry; Reduction and Oxidation; electrochemical cells; Fuel Cells; electrolysis; electroplating; corrosion; Pourbaix Diagrams

Week 14 (Dec. 1 – Dec. 5)

Topic 8: Surfaces and Interfaces
Readings: Part 2; Sections 7.1-7.3; pg. 237-262
Surfaces and Interfaces; Adhesion; Surface functionalization; Synthesis of nanoparticles
MSE 301 Academic Integrity Policy Statement
(adapted from Prof. Thompson’s Policy for MSE 303)

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity (as clarified below). Any work submitted by a student in this course for academic credit will be the student's own work. For this course, the generic University policy is clarified/modified as:

Discussion among students, the professor, TA, former students, and/or any colleagues is permitted and encouraged. You are free to seek help through all avenues. All final work submitted must be almost exclusively your own work. Copying work from any source (a classmate’s homework, previous year’s solutions, a website, etc.) is a violation of this policy.

Violations

Because establishing violations of this policy is difficult, the penalties are sufficiently extreme to discourage the attempt. As such, in this class the following penalties will be assessed for violations:
  First violation: A one grade letter drop in final course grade
  Second violation: An F for the course.

What does this practically mean for collaborations?

It is not the intent of this policy to discourage students teaching and learning from one another. Quite the contrary, I strongly encourage working together to teach one another. It is only to ensure that you do in fact make the effort to learn the material for yourself. If you work on problem sets together, you still must write the solutions for yourself. If you look over someone else’s solution, you need to then go and work the problem out for yourself and put it in your own words and style.

How are violations discerned?

While it is often difficult to find violations, sometimes they are so flagrant that they cannot be missed. We read all of the problem sets and exams, we will notice copied phrases, line-by-line identical solutions, blatant errors that are perpetuated through copying, or material copied directly from websites such as Wikipedia.

Multiple students turning in a problem approached in the same way (correct or incorrect) does not constitute a violation.