CE 463L
Course Syllabus

Fall 2012
Part I Course Organization
Course Description:

This course teaches the student various aspects of aquatic chemistry with emphasis on water quality relevant to water and wastewater treatment systems. The theoretical aspects include the fundamentals of chemical thermodynamics and kinetics, acid-base reaction equilibria, alkalinity and carbonate systems, and precipitation of solids. Furthermore, it provides a solid foundation on the application of acid-base equilibrium (pC-pH) diagrams and solubility diagrams and other aspects of aquatic chemistry relevant to natural systems and engineered systems. The acid-base chemistry, carbonate systems, and precipitation relate to unit processes such as coagulation and flocculation, precipitation of toxic metals, removal of hardness, and treatment of industrial wastes.

The laboratory classes ensure sufficient exposure to various analytical procedures and techniques pertaining to the quantitative determination of chemical constituents of water including: turbidity and color measurements; jar test studies; inorganics (chloride, sulfate, nitrate, and phosphate ions, and free chlorine), TOC analysis, hardness test (calcium and magnesium ions); carbonate system (bicarbonate and carbonate ions) and alkalinity; acids and bases titration; biochemical oxygen demand; chemical oxygen demand; and toxic metal analysis. The course familiarizes the student with the use of sophisticated instrumentation to determine these contaminants at various concentration levels.

Instructor: (Dr. P) - Professor Mike Pirbazari, Ph.D.
Office: KAP 260
Phone: 213-740-0592
E-mail: pirbazar@usc.edu
Class location: KAP 144
Class hours: Tuesday 6:30 to 8:40pm
Office hours: To be determined
(Also, by appointment outside these hours)
Discussion: Wednesday 4:30 to 6:10pm
Lab Sessions: Friday 1:00 to 3:00pm and 3:30 to 5:30pm
Lab Location: Laboratory location PCE 308 and BHE 210

Teaching Assistants: Ryan Thacher
Office: Phone: E-mail:
Office hours:

Grading Criteria:
- Midterm exam (2 @ 10%) 20%
- Final exam 20%
- Quizzes (2 @ 5%) 10%
- Homework assignments 10%
- Lab reports 25%
- Class and lab participation 10%
- Total 100

Textbooks:

References:

Schedule for Quizzes and Exams:

<table>
<thead>
<tr>
<th>Session</th>
<th>Date</th>
<th>Schedule</th>
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<tbody>
<tr>
<td>1</td>
<td>01/12</td>
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<td>2</td>
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<td>4</td>
<td>02/02</td>
<td>Quiz 1</td>
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<td>5</td>
<td>02/09</td>
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<td>6</td>
<td>02/16</td>
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<td>7</td>
<td>02/23</td>
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<tr>
<td>8</td>
<td>03/01</td>
<td>Midterm 1</td>
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<tr>
<td>9</td>
<td>03/08</td>
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<tr>
<td>10</td>
<td>03/15</td>
<td>Spring Break</td>
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<tr>
<td>11</td>
<td>03/22</td>
<td>Quiz 2</td>
</tr>
<tr>
<td>12</td>
<td>03/29</td>
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</table>
Course Topics

I. Introduction to Water Chemistry
   General Properties of Water
   Composition of Different Waters
   Methods of Expressing Concentrations

II. Chemical Equilibrium
   Thermodynamic Basis of Chemical Equilibrium
   Enthalpy, Free Energy, and Equilibrium Constant
   Non-ideal Behavior of Ions and Molecules in Solution

III. Chemical Kinetics
   Reaction Mechanism
   Reaction Rate Laws
   Temperature Effect on Reaction Rates
   Catalysis
   Empirical Rate Laws

IV. Acid-Base Chemistry
   Equilibrium Calculations - General Approaches
   Mass Balance, Charge Balance, and Proton Condition
   Equilibrium Relationships
   Graphical Techniques for Equilibrium Calculations
   Effects of Temperature and Ionic Strength on Equilibria
   Mixtures of Acids and Base Calculations for pH Determination
   pH Buffers and Buffer Intensity
   Carbonate System and Its Equilibria
   Alkalinity and Acidity
   Theory of Acid-Base Titration

V. Precipitation and Dissolution
   Equilibria of Dissolution
   Solubility Product Concept
   Temperature Effect on Solubility
   Common ion Effect
   Complexation and Solubility
   Solubility of Salts
   Solubility Phase Diagrams and Their Applications
Ferrous and Ferric Carbonates and Hydroxides
Theoretical Aspects of Precipitation

VI. Oxidation-Reduction
Redox Stoichiometry, Equilibria and Half Reactions
Free Energy and Potentials of Half Reactions
Nernst Equation and Formation Potentials
Electron Balance and Equilibrium Calculations
Corrosion Cells and Reactions
Corrosion Control

Computer Usage:
The use of IBMPC, MacIntosh, PowerMac or equivalent with graphic capabilities are recommended for preparation of laboratory reports.

Academic Integrity:
The use of unauthorized material, communication with fellow students during an examination, attempting to benefit from the work of another student, and similar behavior that defeats the intent of an examination or other class work is unacceptable to the University. It is often difficult to distinguish between a culpable act and inadvertent behavior resulting from the nervous tension accompanying examinations. When the professor determines that a violation has occurred, appropriate action, as determined by the instructor, will be taken.

Although working together is encouraged, all work claimed as yours must in fact be your own effort. Students who plagiarize the work of other students will receive zero points and possibly be referred to Student Judicial Affairs and Community Standards (SJACS).

All students should read, understand, and abide by the University Student Conduct Code listed in SCampus, and available at: http://web-app.usc.edu/scampus/university-student-conduct-code/

Students with Disabilities:
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your instructor (or to your TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.
# Laboratory Schedule

<table>
<thead>
<tr>
<th>Session #</th>
<th>Date</th>
<th>Experiment #</th>
<th>Experimental Work</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Week of Jan. 9th</td>
<td>1</td>
<td>Laboratory Safety Instructions &amp; Overview</td>
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<tr>
<td>2</td>
<td>Week of Jan. 16th</td>
<td>2</td>
<td>Determination of Turbidity and Coagulant Dosage</td>
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<tr>
<td>3</td>
<td>Week of Jan. 23rd</td>
<td>3</td>
<td>Gravimetric Methods for Solids Analysis</td>
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<td>4</td>
<td>Week of Jan. 30th</td>
<td>4</td>
<td>Determination of Organic Pollutant Mixtures by UV Spectroscopy</td>
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<td>5</td>
<td>Week of Feb. 6th</td>
<td>5</td>
<td>Determination of Total Organic Carbon by TOC Analyzer</td>
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<tr>
<td>6</td>
<td>Week of Feb. 13th</td>
<td>6</td>
<td>Determination of Inorganic Pollutants by Ion Chromatography</td>
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<td>7</td>
<td>Week of Feb. 20th</td>
<td>7</td>
<td>Determination of Hardness by Atomic Absorption Spectroscopy</td>
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<td>8</td>
<td>Week of Feb. 27th</td>
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<td>Midterm 1</td>
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<tr>
<td>9</td>
<td>Week of March 5th</td>
<td>8</td>
<td>Chemical Oxygen Demand</td>
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<td>10</td>
<td>Week of March 12th</td>
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<td>Spring Recess</td>
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<td>11</td>
<td>Week of March 19th</td>
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<td>Activated Sludge Microorganisms Observations by Light Microscopy</td>
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<td>12</td>
<td>Week of March 26th</td>
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<td>Acid-Base Titration Curves &amp; Acid-Base Indicators</td>
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<tr>
<td>13</td>
<td>Week of April 9th</td>
<td>11</td>
<td>Alkalinity and Carbonate System</td>
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<td>14</td>
<td>Week of April 11th</td>
<td></td>
<td>Midterm 2</td>
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<tr>
<td>15</td>
<td>Week of April 16th</td>
<td></td>
<td>Biochemical Oxygen Demand</td>
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<tr>
<td>16</td>
<td>Week of April 23rd</td>
<td></td>
<td>Lab Review - Becoming Familiar with the Standard Methods for the Examination of Water and Wastewater</td>
</tr>
</tbody>
</table>
LABORATORY REPORT INSTRUCTIONS

1. Your laboratory data reports should be presented on 8” x 11” sheets stapled at the left-hand upper corner.

2. All data and experimental write-ups should be word-processed.

3. Laboratory reports will be collected at the beginning of the lab session for the experiment conducted on the previous session.

4. Late laboratory reports will be penalized at 5 points per day.

5. No late report will be accepted one week past the due date.

6. In your laboratory write-up, you must conform to the following format:

   I - The first page of your laboratory report should contain:

   LABORATORY REPORT
   EXPERIMENT #

   Experiment Title
   GROUP #
   YOUR NAME
   DATE

   II - Starting from the second page, the write-up must include the following sections:

   Purpose: (5 pts)
   ● Briefly describe the purpose of the lab, and what the lab aims to accomplish.

   Introduction / Background (10 pts)
• Elaborate on the purpose, and describe with some detail the lab’s significance to water quality engineering. Provide a detailed technical description of the chemical/physical mechanisms that provide the framework of the experiment.

**Methods:** (10 pts)
• Briefly describe the experimental procedure.

**Results / Data:** (15 pts)
• Provide all results obtained during the experiment, this may be data in tabular form, descriptions of observations, or shown in figures (whatever is most appropriate). *Clearly label all figures, charts, or tables!*

**Discussion / Questions (when applicable):** (40 pts)
• Discuss the results of the lab and the implications. In this section, tie together the introduction, methods, and results to describe what happened in the experiment and why. If the data appears to be consistent with what was anticipated, describe why this was anticipated and describe the significance. If the results are inconsistent between classmates or what was anticipated, look into why this may have occurred and how the experimental procedure could have been modified improve upon this.

• *This is the most important section of the lab report. In this section you are required to demonstrate a clear understanding of the concepts involved and the chemical/physical mechanisms, which govern the success of the each experiment.*

• Labs may or may not contain questions regarding the experiment and its significance. These questions must be clearly answered using original wording, and if outside references are used, they must be cited appropriately.

**Conclusion:** (20 pts)
• Briefly summarize the experiment, the results, what was learned, and why it is significant. This should tie everything together in a clear, concise paragraph. Add any final thoughts in this section; *please do not simply repeat what was written in previous sections.*

**Additional Note:**
Please provide original work. All USC plagiarism rules must be observed and will be strictly enforced. Using outside resources to find more information on a subject is encouraged, but make sure to cite them properly.

Effective Class Participation

Please note the following suggestions for effective class participation:

1) Make every effort to interact with your class partner(s).
2) Try to stay active throughout the class period.
3) Don’t hesitate to ask questions in class.
4) Share your ideas with the rest of us.
5) Don’t hesitate to ask the instructor to repeat himself.
6) Keep an eye on your partner not to fall asleep in class!!
7) Try to bring new ideas to class.
8) Don’t read unrelated materials in class.
9) Share your ideas for class improvement with your instructor.
10) Put your fair share of efforts in preparing the term projects and the term paper. Be cooperative at all times.
11) Discuss your term paper and term project with the instructor periodically.
12) Come to class prepared.
13) Help your instructor make the class interesting.
14) Discuss your concerns and problems (if any) about the course with the instructor. He will do his best to accommodate your suggestions.

15) Late homework is not accepted.
16) Use of lap tops in class is not permitted.
Effective laboratory Participation

Please note the following suggestions for effective lab participation.

1. Follow laboratory safety regulations diligently (posted on Blackboard).
2. Wear your lab coat and safety goggles as soon as you arrive.
3. Bring a copy of the lab procedure with you to class (available on Blackboard).
4. Follow the lab procedure succinctly.
5. Be cooperative at all times.
6. Try not to be disruptive.
7. Don’t hesitate to ask questions.
8. Report accidents to the lab coordinators immediately.
9. Late lab reports are not acceptable.
10. Tardiness is not acceptable.
11. Make every effort to make the lab experience enjoyable for yourself and others.

Prepared by: Prof. Mike Pirbazari
Part II  Detailed Course Objectives
Course Information, Textbook, and Supplementary Materials

Course Description: Chemistry of water purification technology and water pollution control. Chemical processes in natural and engineering aquatic environments; physical/chemical and biological characterization of water and wastewater.

Required for: BSCE-ENE and BSENE

Prerequisites: CE 453; and 1 from CHEM-105b or CHEM 115b

Co-Requisite: None

Required Textbooks:
3. Class Notes for CE 463L: Water Chemistry and Analysis, Lectures and Laboratory Experiments; adapted by Professor Mike Pirbazari, Spring 2007.

References:

<table>
<thead>
<tr>
<th>Topics Covered</th>
<th>Learning Outcomes</th>
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<tbody>
<tr>
<td>Introduction to Water Chemistry</td>
<td>Students will learn: 1. General Properties of Water, Composition of Different Waters, and Methods of Expressing Concentrations</td>
</tr>
<tr>
<td></td>
<td>2. Thermodynamic Basis of Chemical Equilibrium, Enthalpy, Free Energy, and Equilibrium Constant, and Non-ideal Behavior of Ions and Molecules in Solution</td>
</tr>
<tr>
<td>Chemical Equilibrium</td>
<td>3. Reaction Mechanism, Reaction Rate Laws, Temperature Effect on Reaction Rates, Catalysis, and Empirical Rate Laws</td>
</tr>
<tr>
<td>Acid-Base Chemistry</td>
<td>5. Precipitation and Dissolution Kinetics, Equilibria of Dissolution, Solubility Product Concept, Temperature Effect on Solubility, Common Ion Effect, Complexation and Solubility, Solubility of Salts, Solubility Phase Diagrams and Their Applications, Ferrous and Ferric Carbonates and Hydroxides, and Theoretical Aspects of Precipitation</td>
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Page 1
Lecture and Lab Schedule

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<th>Lecture</th>
<th>Lab</th>
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<tbody>
<tr>
<td>Sessions per Week</td>
<td>Duration per Session</td>
</tr>
<tr>
<td>1</td>
<td>1.5 hours</td>
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Contribution of Course to Meeting the Professional Component

Engineering Topics | Design
Students will understand the design process and learn approaches used to solve various engineering problems that are representative of those found in a professional environment. They will practice decision-making skills as they apply their knowledge of basic sciences, mathematics, and the engineering sciences to convert resources optimally to meet the stated needs of a project.

In this course, students will learn to design and conduct experiments, as well as to analyze and interpret data. They will also be considering desired needs as it applies to realistic constraints.

Engineering Topics | Other
Constraints and Considerations. Students will understand the diverse constraints and considerations that are representative of what they will encounter in an engineering practice. This course covers the following topics:

- Environmental
- Sustainability
- Health and Safety
- Energy

Relation of Course Objectives to Program Outcomes
The Civil Engineering program is designed to teach beyond the technical content of the curriculum and prepare the students to utilize what they learn in a professional setting.

This course contributes to the program outcomes as outlined in the adjacent table.

<table>
<thead>
<tr>
<th>Course Contribution to Program Outcomes (a-k)</th>
<th>✓ Key</th>
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</thead>
<tbody>
<tr>
<td>a. An ability to apply knowledge of mathematics, science, and engineering.</td>
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<tr>
<td>b. An ability to design and conduct experiments, as well as to analyze and interpret data.</td>
<td>✓</td>
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<tr>
<td>c. An ability to design a system component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.</td>
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<tr>
<td>e. An ability to identify, formulate and solve engineering problems.</td>
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<td>h. The broad education necessary to understand the impact of engineering solutions in a global economic and environmental and societal context.</td>
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<td>i. Recognition of the need for, and an ability to engage in life-long learning.</td>
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<td>j. Knowledge of contemporary issues.</td>
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<tr>
<td>k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
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Prepared by: Dr. Mike Pirbazari
Professor of Environmental Engineering

Date: Fall 2012