CE 463L
Water Chemistry and Analysis

Spring 2011

Instructor: Professor Mike Pirbazari

Sonny Astani Department of Civil and Environmental Engineering

Viterbi School of Engineering
University of Southern California
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 148
Class hours: Thursday 6:30 to 8:40pm
Office hours: Monday 1:00 to 4:00pm & Wednesday 3:00 to 6:00pm
  • also, by appointment outside these hours
Discussion: Wednesday 4:30 to 6:10pm
Lab Sessions: Tuesday, Wednesday, Thursday, and Friday 1:00 to 3:00pm
Lab Location: Laboratory location PCE 308 and BHE 210
Teaching Assistants:  
Ryan Thacher  
Tom Tsai
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:
2. Class Notes for CE 463L: Water Chemistry and Analysis, Lectures and Laboratory Experiments; adapted by Professor Mike Pirbazari. Available on Blackboard.

References:
# Schedule for Quizzes and Exams:

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<th>Session</th>
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<th>Schedule</th>
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<td>16</td>
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<td>05/05</td>
<td>Final Exam: 7:00 to 9:00pm</td>
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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.
# Laboratory Schedule

<table>
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<th>Session #</th>
<th>Date</th>
<th>Experiment #</th>
<th>Experimental Work</th>
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<tr>
<td>1</td>
<td>Week of Jan. 10th</td>
<td>1</td>
<td>Laboratory Safety Instructions &amp; Overview</td>
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<tr>
<td>2</td>
<td>Week of Jan. 17th</td>
<td>2</td>
<td>Determination of Turbidity and Coagulant Dosage</td>
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<td>3</td>
<td>Week of Jan. 24th</td>
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<td>Gravimetric Methods for Solids Analysis</td>
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<td>4</td>
<td>Week of Jan. 31st</td>
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<td>Determination of Organic Pollutant Mixtures by UV Spectroscopy</td>
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<td>5</td>
<td>Week of Feb. 7th</td>
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<td>Determination of Inorganic Pollutants by Ion Chromatography</td>
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<td>6</td>
<td>Week of Feb. 14th</td>
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<td>Determination of Total Organic Carbon by TOC Analyzer</td>
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<td>7</td>
<td>Week of Feb. 21st</td>
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<td>Biochemical Oxygen Demand</td>
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<td>8</td>
<td>Week of Feb. 28th</td>
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<td><strong>Midterm 1</strong></td>
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<td>9</td>
<td>Week of March. 7th</td>
<td>8</td>
<td>Chemical Oxygen Demand</td>
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<td>10</td>
<td>Week of March 14th</td>
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<td><strong>Spring Recess</strong></td>
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<td>11</td>
<td>Week of March 21st</td>
<td>9</td>
<td>Acid-Base Titration Curves &amp; Acid-Base Indicators</td>
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<td>12</td>
<td>Week of March 28th</td>
<td>10</td>
<td>Alkalinity and Carbonate System</td>
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<td>Week of April 4th</td>
<td>11</td>
<td>Activated Sludge Microorganisms Observations by Light Microscopy</td>
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<td>Week of April 11th</td>
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<td>Midterm 2</td>
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<td>Week of April 18th</td>
<td>13</td>
<td>Coliform Bacteria Test</td>
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<tr>
<td>Week of April 25th</td>
<td>14</td>
<td>Lab Review - Becoming Familiar with the Standard Methods for the Examination of Water and Wastewater</td>
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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.

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**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.

17) Tardiness is not acceptable.

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**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.