Problem Set 6

CEEG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills
October 4, 2019

Due Date and Submittal Process

Due Date: Friday, 11 October

Submittal Process: Please submit this assignment as two separate hard copies–i.e., PS 6–Part 1 and PS 6–Part 2. I'm asking you to submit each part of the assignment separately, because I'm grading Part 1 and one of the course graders is grading Part 2. In addition, I recommend that you type your responses to Part 1. Thank you!

Learning Goals

1. Reflect on your learning in this class.
2. Apply principles of water chemistry to calculate alkalinity requirements for coagulation.
3. Size water treatment unit processes used for coagulation.

1 Self Reflection *(40 pts)*

We are about halfway into the course, which is a good time for you to look back and reflect on *your* performance. This reflection should help you see what you have learned and to identify places where you still have questions. In addition, it will provide me with an opportunity to answer your questions.
This self reflection exercise will be graded on completeness and the quality of your response. Please type your answers and submit as a separate document with the problem set. I will grade the reflection and a grader will grade the problems. This is not an evaluation of my teaching. This is a self reflection for you to do on your learning.

1. *Overall assessment*:

   On a scale of 0 to 100 what grade would you give yourself on

   (a) problem sets
   (b) lab reports
   (c) quizzes
   (d) midterm exam
   (e) course overall

   Explain your answers.

2. *Problem Solving and Lab Reports*:

(a) What was the most serious problem that you had completing problem sets and lab reports? How did you deal with this problem? How will you avoid or minimize this problem in the future?

(b) What, if anything, did you learn about problem solving from the homework assignments? If you learned something positive, what was it? If you did not, why do you think homework did not help develop problem solving skills and what would be helpful.

(c) What, if anything, did you learn from writing lab reports and preparing high quality figures? If you learned something positive, what was it? If you did not, why do you think lab assignments did not help develop skills needed to effectively communicate results from laboratory and model fitting studies, and what would be helpful.

3. *Preparation for Quizzes and the Mid-term exam*:

   (a) What was the most serious problem you had in preparing for announced quizzes and exams. How did you deal with this problem? How will you avoid or minimize this problem in the future?

2 Problems (60 pts)

1. *(10 pts)* **Iron Oxidation**–Back to CMFR vs. PFR:
   Textbook: Problem 8.15 (assume that "pseudo first-order rate constant" is simply a first-order rate constant)

2. *(10 pts)* **Alkalinity requirements for coagulation:**
   Textbook: Problem 8.4

3. *(10 pts)* **Sizing a coagulation basin:**
   Textbook: Problem 8.8. **After you solve the problem as written, solve it again for water at a temperature of 24 ^{0}C.**

4. *(10 pts)* Sedimentation

   (a) If the settling velocity of a particle is 0.30 cm/s, and the overflow rate of a horizontal clarifier is 0.25 cm/s, what percent of particles are retained in the clarifier?

   (b) If the flow rate of the water treatment plant is doubled, what percent removal of particles would be expected.

5. ~~*(5 pts)* **FE Formatted (multiple choice) Question—Filtration**~~
   ~~Determine the number of rapid-sand filters to treat a flow rate of~~ $\cancel{75.7 \times 10^3 \frac{m^3}{d}}$ ~~if the design [hydraulic] loading rate is~~ $\cancel{300 \frac{m3}{d \times m^2}}$~~. The maximum dimension is 7.5 m, and the length to width ratio is 1.2:1.~~

   (a) ~~4 filters~~

   (b) ~~3 filters~~

   (c) ~~6 filters~~

   (d) ~~5 filters~~

   ~~Show your work even though you wouldn't have to for the FE.~~

6. *(10 pts)* **Disinfection** *Adapted from Davis and Cornwall* Disinfection

(a) What is the equivalent percent reduction (or removal) for a 2.5 log reduction (or removal) value (LRV) of *Giardia lambia*?

(b) What is the LRV that is equivalent to 99.96 percent reduction?

7. *(10 pts)* **Effect of pH on chlorine dose during disinfection**
When Cl_2 gas is added to water during the disinfection of drinking water, it hydrolyzes water to form hypochlorous acid, HOCl, a weak acid (Eq.1).

$$Cl_{2(\mathrm{gas})} \rightarrow \mathrm{HOCl} + \mathrm{HCl} \tag{1}$$

In addition, hypochlorous acid exists in equilibrium with its conjugate base, hypochlorite (OCl^-), as shown in Eq.2. The pK_a for HOCl is 7.5.

$$[\mathrm{HOCl}] \xrightleftharpoons{K_a} [\mathrm{OCl}^-] + [\mathrm{H}^+] \tag{2}$$

(a) The disinfection power of HOCl is about 90 times higher than its conjugate base OCl^-. If a disinfection process requires an HOCl dose of 10 mg/L, what is the required dose of chlorine gas ($Cl_{2(g)}$) in units of mg/L for

i. a source water with pH = 7.5

ii. a source water with pH = 6.5

Note that the dose of HOCl required (10 mg/L) refers to the concentration of the undissociated form of hypochlorous acid at equilibrium (Eq.2).

(b) Use Excel or KaleidaGraph to plot the fraction of free chlorine that is un-dissociated as a function of pH, for pH values between 4 and 12.