

ENV 4001: Environmental Systems Engineering

Spring 2012
Problem Set #1
Finish by Wed., Jan. 25, 2012

University of South Florida
Civil & Environmental Eng.
Prof. J. A. Cunningham

This problem set will not be collected or graded. Your reward for completing this problem set is that it is essential for learning the course material and passing the quizzes and final exam.

(1)

- (a) Answer problem 3-6 in your text book. Hint #1: the total mass of TCE in the vial after the system equilibrates is equal to the total mass of TCE in the system when it is first introduced. Hint #2: the mass of TCE in the water is equal to the volume of the water times the concentration of TCE in the water.
- (b) Answer problem 3-12 in your text book. Hint: notice that the requirement is 1 mg/L of P, not 1 mg/L of PO_4^{3-} . What would be the corresponding concentration of PO_4^{3-} ?

(2) For this problem you may assume a temperature of 25 °C.

- (a) A water contains 40 mg/L of Mg^{2+} . We want to reduce the concentration of Mg^{2+} in the water, so we raise the pH to 11. What will be the concentration of magnesium ion at that point? Report your answer in units of mg/L. You may assume that the magnesium precipitates as $\text{Mg}(\text{OH})_2$.
- (b) Groundwater at a particular location contains iron, Fe^{3+} , at a concentration of 1.80 mg/L. We want to raise the pH in order to precipitate out some of the iron as $\text{Fe}(\text{OH})_3$. What pH is required to reduce the iron concentration to 0.30 mg/L?

(3)

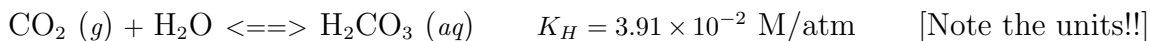
- (a) Balance the following oxidation/reduction (redox) reaction.



- (b) What concentration of propionate ($\text{CH}_3\text{CH}_2\text{COO}^-$) would be required to react with 250 mg/L of sulfate? Report your answer in mg/L.

(4) Our air contains carbon dioxide (CO_2) at a concentration of approximately 380 parts per million by volume (ppmv).

- (a) What is the partial pressure of CO_2 in the air? Report your answer in units of atm, Pa, and torr.
- (b) Convert the concentration to units of mg/m^3 , assuming an air temperature of 20°C .
Hint: use the ideal gas law along with the partial pressure you found in part (a).
- (c) This concentration of CO_2 in the atmosphere has an effect on the pH of rain drops that form in the atmosphere. Consider the following chemical reactions:



Based on these reactions, and given the CO_2 concentration of 380 ppmv, determine the pH of rain water that is in equilibrium with the air. Is rain water acidic or basic? Hint: you have three unknowns: $[\text{H}_2\text{CO}_3]$, $[\text{H}^+]$, and $[\text{HCO}_3^-]$. You are given two equilibrium equations. Therefore you need one more equation to solve the problem. The third equation is based on electroneutrality, and the important result is that $[\text{H}^+] = [\text{HCO}_3^-]$. With this third equation, you should be able to solve the problem. Note that you won't always have $[\text{H}^+] = [\text{HCO}_3^-]$, so don't assume that is a general rule, but it works in this particular case (for reasons we won't go into here).

- (5) One of Prof Cunningham's former students wrote his doctoral dissertation about a new technology to clean up soil contaminated by certain types of chemicals. One of the chemicals we tested in the lab was 1,2,4,5-tetrachlorobenzene (TeCB).
- (a) Draw the chemical structure of 1,2,4,5-tetrachlorobenzene.
- (b) When we started working on the project, we thought maybe TeCB would be destroyed according to first-order kinetics, but we weren't sure. Below are two tables of actual data that the student collected in the laboratory. The two data sets were collected under different experimental conditions. For each of the two experiments, determine if the disappearance of TeCB is zero-order, first-order, second-order, or something else. Specify the value of the rate constant (k_0 , k_1 , or k_2 , as appropriate). Be sure to give the right units of k !

Table 1: Concentration of TeCB vs. time, experiment 1

time (min)	Conc. (mg/L)
0	5.0
5	2.93
10	2.06
20	0.61
30	0.28
45	0.057

Table 2: Concentration of TeCB vs. time, experiment 2

time (min)	Conc. (mg/L)
10	3.02
20	2.51
30	2.16
45	1.59
60	1.07

If you want to know more about this project, read the following paper:

Wee HY, Cunningham JA, 2008. Palladium-catalyzed hydrodehalogenation of 1,2,4,5-tetrachlorobenzene in water-ethanol mixtures. *Journal of Hazardous Materials*, vol. 155, pp. 1–9.

- (6) This problem is like a “bonus.” If you are particularly interested in this topic, I think you will learn something valuable from completing these. However, this material is not as likely to be emphasized in class or on the quizzes and exam.
- (a) Go to the following web site: <http://www.epa.gov/lawsregs/laws/index.html>. According to this web site, how many different laws does the United States Environmental Protection Agency (US EPA) administer (in whole or in part)? Hint: some of the laws are listed under more than one name, so don't double-count them.
 - (b) Which of these laws is primarily concerned with protection of the quality of our surface water bodies (e.g., rivers and streams)? When was that law passed, and when was it significantly amended?
 - (c) Click the link to the text of the law as written by Congress. The actual law is quite long, of course, and you don't have to read it. However, look at the very beginning of the law – what is the stated “objective of this Act”?
 - (d) What are the three components of a Water Quality Standard as defined under this act? Briefly describe what each of these three components is or what it does.