Problem Set 3

CEEG 340–Introduction to Environmental Engineering

Instructor: Deborah Sills

Fall 2017

Due Date

Thursday 14 September 2017

Learning Goals

1. Apply the principle of 'conservation of mass' to balance chemical equations.
2. Use the principle of conservation of mass to write mass balance equations.
3. Apply the general mass balance equation to calculate mass fluxes and concentrations of contaminants.

Questions

1. **(15 points)** (modified based on Mihelcic and Zimmerman) When Cl_2 gas is added to water during the disinfection of drinking water, it hydrolyzes water to form HOCl, a weak acid. The disinfection power of HOCl is 88 times better than its conjugate base OCl^-. The pK_a for HOCl is 7.5. If 15 mg of total HOCl was added per every liter of water being treated, what fraction of the HOCl is not dissociated to its conjugate base OCl^- and H^+?
   Answer: 0.76 (or 76 %) at pH = 7
2. **(12 pts)** Express 50 mg/L of HCO_3^- as:
   - equivalents/liter
   - moles/liter
   - milligram/liter as $CaCO_3$
3. **(10 points) FE Exam Formatted Problem** Estimate the approximate alkalinity, in mg/L as $CaCO_3$, of water with a carbonate ion concentration of 17.0 mg/L and a bicarbonate ion concentration of 111.0 mg/L.
   (a) 119 mg/L as $CaCO_3$
   (b) 128 mg/L as $CaCO_3$
   (c) 148 mg/L as $CaCO_3$
   (d) 146 mg/L as $CaCO_3$

Note that "approximate alkalinity" means that you should ignore $[OH^-]$ and $[H^+]$. Show your work even though you wouldn't have to for the FE.

4. *(16 points)* A tanker truck carrying ethanol has a crash and spills 500 lbs of ethanol into a river adjacent to the road. The good news is that if enough oxygen is available, all of the ethanol will be biodegraded by native aerobic microbes in the river. The unbalanced chemical reaction is:

$$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$$

If all of the ethanol in the river is biodegraded (and converted to CO_2 and H_2O), calculate

   (a) kg of oxygen consumed *Ans: 474 kg*

   (b) kg of CO_2 produced *Ans: 435 kg*

   (c) cubic meters of CO_2 produced at 1 atm and 30 ^{0}C? *Ans: 245 m^3*

5. *(15 pts)* An industrial plant discharges 100 kg/day of liquids into a disposal pond. Measurements show that 1 kg/day seeps out of the bottom of the pond into the ground and 2 kg/day evaporates into the air. What is the rate of mass accumulation in the pond?
Answer: 97 kg/day

6. *(15 pts)* **FE Formatted Question**
A 350 m^3 retention pond that holds rainwater from a shopping mall is empty at the beginning of a rainstorm. The flow rate out of the retention pond must be restricted to 320 L/min to prevent downstream flooding from a 6-hour storm. What is the maximum flow rate (in L/min) into the pond from a 6-hour storm that will not flood it.

   (a) 5,860 $\frac{L}{min}$

   (b) 321 $\frac{L}{min}$

   (c) 1,290 $\frac{L}{min}$

   (d) 7,750 $\frac{L}{min}$

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