Problem Set 2a
CEEG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills
August 28, 2017

Due Date

Friday, 1 September 2017

Learning Goals

1. Calculate chemical concentrations in water in units of mass/mass, mass/volume, mole/volume, ppm_m.

2. Apply kinetic equations to analyze changes in concentrations of chemicals over time.

Questions

1. **(13 pts)** What is the molar concentration of 10 grams/liter for each of the following chemicals?

   - NaOH
   - Na_2SO_4
   - $K_2Cr_2O_7$
   - KCl

2. **(13 pts)** (modified from Mihelcic and Zimmerman) Coliform bacteria (for example, *E. coli*) are excreted in large numbers in human and animal feces. Water that meets a standard of less than one coliform per 100 mL is considered safe for human consumption. Is a 1 m^3 water sample that contains 9000 coliforms safe for human consumption? **Show your work.** *Answer: water is safe.*

3. **(13 pts)** Vinyl chloride is used to produce polyvinyl chloride (PVC), which is a plastic material used in construction. Vinyl chloride is classified as a known carcinogen by the U.S. Environmental Protection Agency (EPA), and according to their website, "EPA has set an enforceable regulation for vinyl chloride, called a maximum contaminant level (MCL), at 0.002 mg/L or 2 ppb_m." Prove that 0.002 mg/L equals 2 ppb_m.

4. **(13 pts)** Text: 2.13, part (a) only. Note that M is mole/L.

5. **(13 pts)** Text: 2.15
   Answers: 15.85 mg/L; 15,850 ppb_m; 2×10^{-4} mole/L

6. **(15 pts)** (adapted from Mihelcic and Zimmerman) A researcher from ETH Zurich recently discovered a microbe that can degrade methylcylclohexanemethanol (MCHM). This microbe destroys MCHM with a rate that follows a first-order reaction with a rate constant of 0.01 day^{-1}.

   (a) How many days will it take for 90 percent of the MCHM to be destroyed?

   (b) How long will it take for 99 percent of the MCHM to be destroyed?

   (c) How long will it take for 99.9 percent of the MCHM to be destroyed?

7. **(20 pts)** A storage facility was abandoned 19 years ago. During its active life, oil was routinely spilled and historical records estimate that the oil concentration in the soil was as high as 400 mg/kg at the time the facility closed. Now a fast food chain wants to build a restaurant at this location. Soil samples indicate that the soil is still contaminated with 20 mg/kg of oil. A local engineer concludes that the oil is still being biodegraded by soil microbes at a rate of 20 mg/kg each year, and that in one more year, the site will be "oil–free."

   (a) *If* correct, what would be the technical basis for the engineer's conclusion? Note that you'll need to provide calculations to support your answer.

   (b) Now assume the engineer is wrong, provide appropriate "worst–case" calculations and determine how long it could take (from the time of facility shut–down) to reach a concentration of 1 mg/kg.

8. **(Extra Credit 10 pts)** Derive the integrated form of a second order rate equation starting with the following differential form:

$$\frac{dC}{dt} = -kC^2 \tag{1}$$