Problem Set 2b

CEEG 340–Introduction to Environmental Engineering

Instructor: Deborah Sills

August 28, 2017

Due Date

Wednesday 6 September 2017

Learning Goals

1. Calculate chemical concentrations in water in units of mass/mass, mass/volume, mole/volume, ppm_m, and in air, in units of ppm_v, mass/vol, and partial pressure.
2. Apply Henry's Law to calculate concentrations of volatile chemicals in air and water.
3. Calculate concentrations and pH of strong acids.
4. Apply equilibrium to calculate concentrations of weak acids and bases.
5. Calculate concentrations of alkalinity in units of eq/L and as $CaCO_3$.

Questions

1. **(15 pts)** Text: 2.14
   answers: 1.25 ppt_m, 8.0×10^6 ppt_m, 2.52×10^5 ppt_v, 250,000 ppt_m
2. **(15 pts)** Text: 2.20
   answer: 3.2×10^{-17} atm
3. **(25 pts) Who loves hockey?** (modified from Mihelcic and Zimmerman)
   Ice resurfacing machines (aka Zambonis) use internal combustion vehicles that give off exhaust containing carbon monoxide (CO) and nitrogen oxides (NO_x). The outdoor air quality 1-h standard of CO is set at 35 mg/m^3. Average CO concentrations measured at Lynah Rink (at Cornell University) have been reported to be as high as 115 ppm_v and as low as 35 ppm_v. (1) Should Prof. Sills be concerned about spending 1 h at Lynah Rink when she watches Cornell's Women's Hockey Team beat Harvard this season? Assume the temperature equals 20^0C. (2) Calculate the partial pressure (in atm) of CO in the rink. Assume that the atmospheric pressure is 1 atm.
4. **(25 points)** Researchers who study microbial degradation of vinyl chloride (VC) use small sealed glass bottles to keep VC from partitioning into the room air during experiments. Once, while I was working in a lab, a new master's student walked up to me to show me that her sealed bottle was open (true story). After the seal broke the bottle contained 3 mg of vinyl

chloride in 60 mL of water.

Assume the volume of air in the lab equaled 100 m^3 and that there was no ventilation (luckily that was not true), the temperature and pressure in the lab were 25 ^{0}C and 1 atm, respectively. In addition, Henry's Law Constant equals 26.8 $\frac{L \times atm}{mole}$.

- Compare the equilibrium concentration of VC in the air to the 3-h air quality standard of $[VC]_{std} = 10$ ppm_v. *Ans: 21,400 ppm_v*
- What should the new master's student have done, when she noticed the seal on the bottle that contained VC was open?

5. **(20 points)** Acid-Base Chemistry

   (a) What is the pH of of a 100 mL solution with 10 mg/L of sulfuric acid (H_2SO_4)?

   (b) What is the normality of the sulfuric acid solution (note that 1 normal (N) equals 1 eq/L)?