

CHEM 301 Assignment #1

Provide solutions to the following questions in a neat and well organized manner.

Reference data sources for any constants and state assumptions, if any.

Due date: Thursday, Sept 27th, 2018

1. It is often said that ‘one drop of motor oil will contaminate a million times its volume in water’. Given that motor oil is a complex mixture of individual aliphatic and aromatic hydrocarbons with an average composition of $C_{20}H_{30}$ and density of 0.87 kg/L, estimate the concentration of oil in this solution in units ppm and micromolar.

2. Alkalinity of a freshwater sample is a measure of its acid neutralizing ability and is primarily due to the presence of hydrogen carbonate ion (HCO_3^-). A water sample obtained from an area of dolomitic limestone $CaMg(CO_3)_2$ has a pH of 8.2 and a *total alkalinity* of 2.3 mM of H^+ . If dolomite is the source of all of the major ions present, use your knowledge of chemical speciation of carbonic acid (Figure 1.2, textbook) and charge balance to calculate the concentration of the major ions.

3. a) Using the speciation diagram for mercury (II) chloro species (Figure 1.3, textbook), predict the aqueous chloride ion concentration in mg/L at which Hg^{2+} is no longer the dominant chemical speciation. Are these conditions more likely to be met in rain, surface, or groundwater?

b) The hydroxides, carbonates and sulfides of cadmium are insoluble and less likely to be mobile in the environment (Figure 1.6, textbook). However, their solubility is strongly influenced by pH and in the case of $CdS(s)$ by the pe. Explain using balanced chemical equilibria to illustrate your answer.

4. Using the appropriate equilibrium constant/s, sketch a labeled pH speciation diagram for hypochlorous acid and calculate the ratio of hypochlorous acid ($HOCl$) to hypochlorite ion at pH 8.20. If an operator has determined that the total concentration of active chlorine (+I) is 1.00 ppm as Cl_2 , what is the concentration the more powerful disinfecting form $HOCl$.

5. The following summarizes the concentrations in mg/L of species from the Colorado River. The pH was 8.3 and the *total alkalinity* was determined to be 140 mg/L as $CaCO_3$.

| Ca^{2+} | Mg^{2+} | Na^+ | Cl^- | SO_4^{2-} |
|-----------|-----------|--------|--------|-------------|
| 77 | 29 | 98 | 88 | 250 |

Calculate the *total hardness* of this sample as mg/L of $CaCO_3$ and determine the fraction of this which is said to be ‘permanent’ (i.e., remains after boiling).

6. To measure the volume of a small lake, you add 5.0L of a 2.0M solution of a non-toxic dye which degrades by first order processes with a half-life of 3.0 days. After one week, in which the lake becomes well mixed, you take a 100. mL lake sample. The dye concentration in this sample is 2.9×10^{-6} M. Estimate the lake volume and state any assumptions.

7. Calculate the volume of water originally containing 10. mg O_2 /L that would be completely depleted of O_2 if 100. kg of cane sugar (sucrose, $C_{12}H_{22}O_{11}$) is accidentally spilled into a water body. State any assumptions. Would you expect such an accident to have a greater or lesser impact in warmer waters? Explain.

8. The following is an analysis report for a wastewater sample. The pH was not provided. Set up and use an Excel spreadsheet to answer the following.

| Species | Concentration (mg/L) | Units reported |
|-------------|----------------------|----------------|
| NH_3 | 0.08 | as N |
| NO_2^- | 0.008 | as N |
| NO_3^- | 2.0 | as N |
| Na^+ | 227 | as Na |
| K^+ | 18.3 | as K |
| F^- | 21.2 | as F |
| Cl^- | 24.1 | as Cl |
| HCO_3^- | 15 | as C |
| Ca^{2+} | 1.7 | as $CaCO_3$ |
| SO_4^{2-} | 20 | as SO_4 |

a) Calculate the mequiv/L of positive and negative charge and express the charge balance as a % error. Comment.

$$\% \text{ error} = \frac{\sum \text{cations} - \sum \text{anions}}{\sum \text{cations} + \sum \text{anions}} \times 100\%$$

b) Calculate the ionic strength (I) of this solution.

c) If H^+ and OH^- are the only ions missing from the analysis, what must the values of their activities be, given that K_{eq} for the dissociation of water is $10^{-14.0}$ at 25 °C. Calculate the activity co-efficients using the appropriate equation, based on the ionic strength.