CEE 543 Aut 2012 HW#1

1. (a) Express the concentration of Ca^{2+} in the Mississippi River (composition shown in Table 1.1) in moles of Ca^{2+} per liter and in milligrams per liter *as* $CaCO_3$.

   (b) The concentration of K^+ is not given in the table. If the charge imbalance were attributable entirely to K^+, what would its concentration be? Note that, in the table, the HCO_3^- concentration is expressed in terms of alkalinity *as* $CaCO_3$. For waters at near-neutral pH such as this one, the assumption is commonly made that the alkalinity is contributed entirely by bicarbonate (HCO_3^-) ions. Each mole of $CaCO_3$ has two equivalents of alkalinity, whereas each mole of bicarbonate has only one. Therefore, to compute the molar concentration of HCO_3^- in the river, you must convert the given alkalinity from mg/L as $CaCO_3$ to meq/L, then assume that the concentration of HCO_3^- in meq/L is the same as the alkalinity in meq/L, and finally convert from meq/L of HCO_3^- to mmol/L of HCO_3^-.

   (c) Based on your result for part (b), what is the TDS of the water in milligrams per liter? Assume that during the drying of the sample, all the HCO_3^- undergoes the reaction $2\,HCO_3^- \leftrightarrow H_2O + CO_2 + CO_3^{2-}$. The H_2O and CO_2 generated by this reaction are volatilized (i.e., transferred to the gas phase), but the CO_3^{2-} remains as part of the dry solid residual, as do all the other ions in the original solution.

   (d) Compute the ionic strength of the river water, if the K^+ concentration is the value computed in part (b), and determine the activities of Ca^{2+}, SO_4^{2-}, and Cl^-, using the Davies equation to estimate activity coefficients.

2. A river contains 8 mg/L DOC in molecules whose average composition is $C_{10}H_{15}O_4N$.

   (a) What is the mass fraction of C in the organic molecules? What is its mole fraction?

   (b) What are the mass fraction and mole fraction of these molecules in the whole solution?

3. If the concentration of silver in seawater is 50 parts per trillion, and the total volume of seawater in the oceans of the world is approximately 1370 x 10^6 km^3, determine:

   (a) the total mass (kg) of silver in the oceans of the world;

   (b) the total volume of seawater that you would have to process to recover one kilogram of silver, assuming an extraction process with 100% efficiency.

4. The partial pressures of nitrogen (N_2), oxygen (O_2), and carbon dioxide (CO_2) in air are 0.78 atm, 0.21 atm, and $10^{-3.5}$ atm, respectively.

   (a) Calculate the mass (mg) of each of these components in 1 L of air at 25°C.

   (b) Calculate the concentration in air at 25°C of each of these components in $\mu g/m^3$.