Environmental Chemistry, Homework set

Acid-base, carbonate system

1)) Do the alkalinity and pH of water in a closed system increase, decrease or stay constant upon addition of:

i. NaOH
ii. Na_2CO_3
iii. CO_2
iv. Na_2SO_4

b) Calculate the alkalinity of the following solutions:

i. 5 mM NaCl
ii. 5 mM HCl
iii. $C_T = 10^{-4}$ M; pH = 6.4 (closed system, 25˚C)

2) An anaerobic groundwater, isolated from the atmosphere and at a temperature of 5°C, consists of only water and hydrogen sulfide (H_2S).

a) What is the pH of this water if the total concentration of sulfide ($H_2S + HS^-$) is 10^{-5} M ? You can assume that all sulfide was added as hydrogen sulfide (H_2S).

b) Now the groundwater flows into a region where boric acid dissolves into the water. The boric acid is added in the acidic form, and that the total boric acid concentration ($B(OH_3) + B(OH)_4^-$) is 10^{-2} M. What is the new pH of the groundwater?

Use the graphical method and the plot provided to answer these questions.

Some useful information

T = 5°C

$H_2S \rightarrow HS^- + H^+$ $\quad pK_a = 7.1$

$B(OH)_3 \rightarrow B(OH)_4^- + H^+$ $\quad pK_a = 9.3$

3) A river flows over a terrain with different mineralogical properties, and it rapidly reaches equilibrium with the minerals present.

a) First, the terrain is dominated by $MgCO_3$. What is the pH and Mg^{2+} concentration of the river?

b) Further downstream, the terrain is now composed not only of $MgCO_3$, but also $CaCO_3$, and the river is in equilibrium with both. What are the pH and Mg^{2+} now?

c) Even further downstream, the terrain changes and the river is now in equilibrium with only dolomite, $MgCa(CO_3)_2$. What is the pH of the river now?

Some useful information

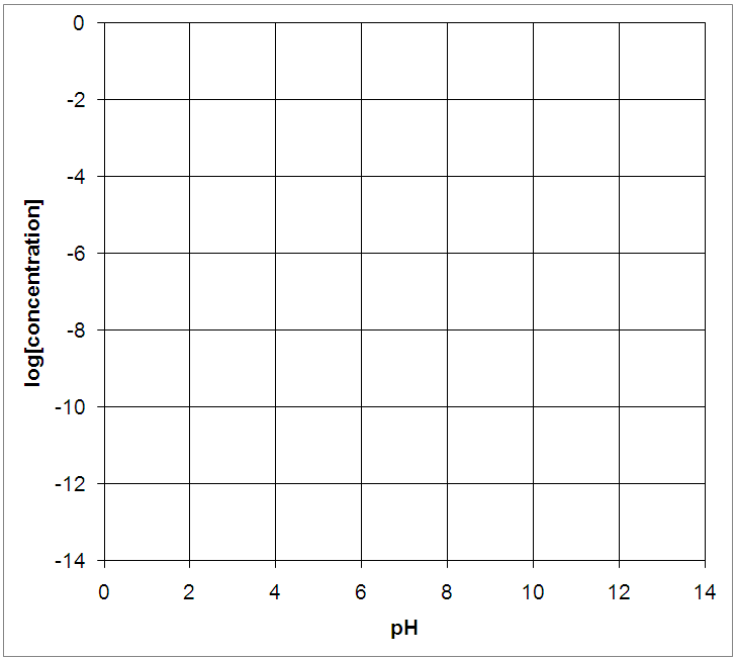
Temperature = 25° C

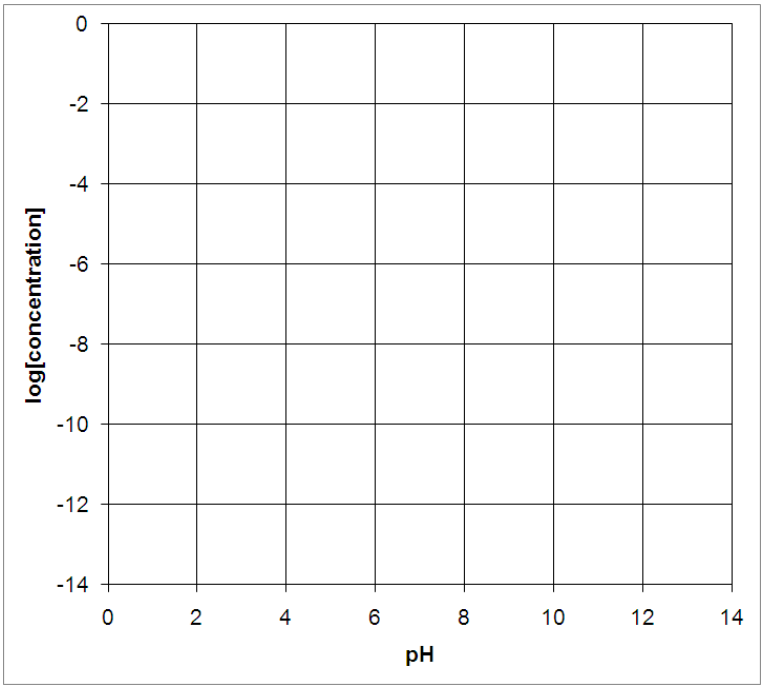
$p_{CO2} = 10^{-3.37}$ atm

pK_{s0} ($MgCO_3$) = 7

pK_{s0} ($CaCO_3$) = 8.42

pK_{s0} ($CaMg(CO_3)_2$) = 17





4) A stream (T = 25°C) has a pH of 8.3 and is in equilibrium with both the atmosphere and with $CaCO_3$ in the sediment. An acidic wastewater containing 20 mM nitric acid (HNO_3, a very strong acid) and no carbonate is to be discharged into the stream. What is the most wastewater that can be discharged per liter of stream water if the pH of the stream may not drop below 7 ?

You can use any simplifications or graphs discussed during class to help answer this question.