

### Work Session 18: Acid-Base Equilibria

1. What is the pH and the pOH of each of the following solutions? To make sure you are on the right track, show the  $[H_3O^+]$  and  $[OH^-]$  for each solution, as well as the pH and pOH. If there is a weak acid here, look up its  $K_a$ , then solve the problem.

0.050M HCl

0.25M NaOH

2.5M  $HNO_3$

0.050M HClO

2. Write the formula for the conjugate base of each of the following:

HCl

$H_2O$

$H_2PO_4^-$

$NH_4^+$

3. Write the formula for the conjugate acid of each of the following:

$F^-$

$H_2O$

$H_2PO_4^-$

$CH_3NH_2$

4. For each of the following weak acids, show them reacting using the form:  $HA \rightleftharpoons H^+ + A^-$ . Use the values of their  $K_a$ 's to list them in order of how strongly they do this, placing the strongest one first.

$HBrO$ ,  $K_a = 2.3 \times 10^{-9}$

$HCHO_2$ ,  $K_a = 1.8 \times 10^{-4}$

$H_3BO_3$ ,  $K_a = 5.8 \times 10^{-10}$

5. Show a reaction between one of the acids in question 4 with one of the conjugate bases that favors the product side. Show a reaction between one of the acids in question 4 with one of the conjugate bases that favors the reactant side. Notice that the stronger acids are on top, left of the reaction arrow, and the stronger bases are lower, right of the arrow. See Section 18.3 and Figure 18.10 in the text.

6. Nitrous acid,  $HNO_2$ , is a weak acid. A 0.50M solution of the acid has a pH of 1.83. What is the  $K_a$  of nitrous acid from this data?

7. Dimethylamine,  $(CH_3)_2NH$ , is a weak base with a  $K_b = 5.9 \times 10^{-9}$ . What is the pH of a 0.20M solution of the base? In solving this problem, show the value for the  $[OH^-]$ , the pOH, and the pH.

8. For each of the following acids, a sodium salt of the conjugate base is shown. Write the formula for the conjugate base alone, and give its  $K_b$ .

$HClO_2$ ,  $K_a = 1.8 \times 10^{-4}$ ;  $NaClO_2$

$HCN$ ,  $K_a = 6.2 \times 10^{-10}$ ;  $NaCN$

9. For each of these salts, predict if they form acidic, neutral, or basic water solutions. Give the reason for your prediction.
- $\text{KNO}_3$
- $\text{KNO}_2$
- $\text{NH}_4\text{Cl}$
- $\text{CuCl}_2$
- $\text{CuF}_2$
10. Which of these acid pairs is stronger? Why?
- $\text{HClO}_3$  or  $\text{HClO}_2$
- $\text{H}_2\text{Te}$  or  $\text{H}_2\text{S}$
11. When  $\text{NaClO}$  dissolves in water, what happens first? Of the two ions formed, does either react with water? Show the equilibrium reaction for this ion reacting with water. After the equilibrium is established, there will be a number of ions and a molecule in the solution, namely  $\text{Na}^+$ ,  $\text{ClO}^-$ ,  $\text{H}_3\text{O}^+$ ,  $\text{OH}^-$ , and  $\text{HClO}$ . Compare the quantities of each of these ions to one another. In a 0.70M solution of  $\text{NaClO}$  (Clorox), what would be the numerical values of each of these concentrations?
12. Repeat this exercise using  $\text{NH}_4\text{Cl}$  as the substance dissolving in the water. Write out and compare the quantities of the ions and molecules in the solution.
13. Write out and compare the three definitions used for acids and bases: The Arrhenius, the Brønsted-Lowry, and the Lewis definitions.