

Problem Set #7 – Chemistry 102 – Spring 2008

Due on Wednesday, April 9th at the beginning of class

1. Determine whether each of the following reactions is an acid/base reaction, and if so, identify the conjugate pairs of acids and bases, and label them accordingly:

- $\text{C}_5\text{H}_5\text{N}_{(\text{aq})} + \text{HCO}_2\text{H}_{(\text{aq})} \rightleftharpoons \text{C}_5\text{H}_5\text{NH}^+_{(\text{aq})} + \text{HCO}_2^-_{(\text{aq})}$
- $\text{Fe}(\text{H}_2\text{O})_6^{3+}_{(\text{aq})} + \text{CN}^-_{(\text{aq})} \rightleftharpoons \text{Fe}(\text{H}_2\text{O})_5(\text{OH})^{2+}_{(\text{aq})} + \text{HCN}_{(\text{aq})}$
- $(\text{CH}_3\text{O})_3\text{BH}^+_{(\text{aq})} + \text{CH}_2\text{NH}_2^+_{(\text{aq})} \rightleftharpoons (\text{CH}_3\text{O})_3\text{B}_{(\text{aq})} + \text{CH}_3\text{NH}_2_{(\text{aq})}$

2. Calculate:

- The pK_a of an acid with K_a of 2.9×10^{-5} M.
- The pH of a solution of 0.0010 M NaOH
- The K_b of the conjugate base of an acid with a pK_a of 9.8.
- The concentration of OH^- in a solution of 0.20 M HCl.
- The pH of a solution of a 0.10 M solution of the acid in part “a”.
- The pH of a solution of a 0.10 M solution of the base in part “c”.

3. For each of the following:

- Predict whether the salt will create an acidic, neutral or basic solution.
- Write the appropriate net ionic equation showing the reaction of the acid or base with water (you don't need to do this for the compounds that don't effect solution pH).

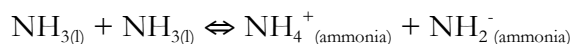
- a. NaNO_3 b. KF c. NH_4Br d. Na_2HPO_4

4. Because of the effects of salt concentration in sea water, its pK_w is 13.776 at 298 K. Calculate the concentrations of hydronium ion and hydroxide ion in neutral sea water. The pH of sea water is 8. What is the hydroxide ion concentration (you do need to know K_w)?

5. Write balanced acid/base reactions for the following pairs of compounds and predict their equilibrium constants using pK_a data from Appendix F in the text. State explicitly whether the reaction is product or reactant favored.

- NH_3 and HNO_2
- OH^- and acetic acid ($\text{C}_3\text{H}_8\text{O}_2$ or HOAc)
- HSO_4^- and HCO_3^- (there are two possible acid/base reactions for this pair – evaluate both).

6. Ammonia is an amphoteric compound, much like water, and undergoes an autodissociation reaction in its pure liquid state:



a. Give that the pK_a of NH_3 is estimated to be 34 and the pK_a of NH_4^+ can be estimated to be 9, provide a rough estimate of the equilibrium constant for the autodissociation of NH_3 (note that the concentration of ammonia in liquid ammonia is about 40 M (that is, there are 40 moles of NH_3 in 1 L of liquid ammonia)).

b. Acetic acid (HOAc) is a weak acid in water (pK_a 4.7). Would it be considered a weak acid in liquid ammonia? Write down the acid dissociation reaction of acetic acid in liquid ammonia and calculate the equilibrium constant for that reaction, using data provided in this problem, in making your argument.