CH302 Spring 2008 Worksheet 5

14 questions involving simple acid base equilbria and the approximations that make them simple.

1. The only water equilibrium for which we make no approximations is the case of pure water (amazing how simple something is when you don't add anything to it.) What is the most common approximation made when we add acids or bases to water?

2. For each of the compounds and concentrations shown below, tell what kind of compound it is (strong acid, weak acid, strong base, weak base, salt) and write down the equation you would use to solve the problem.

compound	type	equation
0.2 M $HClO_3$		
0.1 M NH_4Cl		
0.03 M $Ba(OH)_2$		
0.2 M CH_3NH_2		
0.2 M lithium acetate		
0.1 M lactic acid		

3-9. For the next six problems, find the pH of the compound for the compounds in Table 2. Assume a simple equilibrium in each case. You will note that the total time and uncertainty involved in solving these six problems will probably be less than the time and doubt involved in completing Table 2. This should be a heads up to you that the biggest reason people struggle in this section of material is that they don't know what kind of problem they are working—and we haven't even started dumping multiple compounds into solution!!

3. What is the pH of 0.2 M $HClO_4$?

4. What is the pH of 0.1 M NH_4Cl? The pK_b of NH_3 is 4.75.

5. What is the pH of 0.03 M $Ba(OH)_2$? (Hint, there are 2 OH^- dumped into solution for each $Ba(OH)_2$.)

6. What is the pH of 0.2 M CH_3NH_2 if the pK_b is 3.8?

7. What is the pH of 0.2 M $HClO_4$?

8. What is the pH of 0.2 M lithium acetate if the pK_b is 9.3?

9. What is the pH of 0.1 M lactic acid if the K_a is 1.4 x 10^{-4}?

10. Chemical species in acid and base reactions can all be simplified into the following six forms.

H^+ HA BH^+ B A^- OH^-

Many of you will not think it is necessary to learn this simple notation, but that is because we haven't dealt with buffers and neutralizations yet. So for the mean time, learn what the symbols mean and finding an example of each of these symbols in question 2.

One example is provided to get you started.

abbreviation	type	example	equation
H^+			
HA			
BH^+			
B			
A^-	charged weak base	0.2 M lithium acetate	$[OH^-] = (K_bC_b)^{0.5}$
OH^-			

Enough on equations of simple (single compound) equilibria. Not it is time to think about approximations that make simple equilibrium equations possible. This isn't on Exam 1 but it is worth thinking through to really understand what we are trying to do with the calculations.

11. Derive the weak acid equation ($[H^+] = (K_aC_a)^{0.5}$) by placing C_a for the concentration of weak acid into the RICE expression and solving:

R	$HA \rightarrow$	H^+	+ A^-
I	C_a		
C			
E			

12. During the derivation in problem 11 you made two approximations. In which boxes of the RICE expression did these approximations occur and what were the approximations? Can you suggest a general rule for when the approximations will hold based upon the notion that 1% error is permissible?

13. For the various combinations of weak acid K_a and concentrations shown below, indicate the ones that can be solved using the equation $[H^+] = (K_aC_a)^{0.5}$ because the approximations we made in the derivation hold. If you can't use the approximation, explain why. (Note, you won't circle very many, which tells you how careful we have to be teaching freshman chemistry to make sure our questions are just right.)

acid	Ka	concentration	Reason $[H^+] = (K_aC_a)^{0.5}$ doesn't work
chlorous acid	1.2×10^{-2}	1 M	
chlorous acid	1.2×10^{-2}	1×10^{-2}M	
chlorous acid	1.2×10^{-2}	1×10^{-7}M	Doesn't work, K is too large and [ ] is too dilute
formic acid	1.8×10^{-4}	1 M	
formic acid	1.8×10^{-4}	1×10^{-2}M	Can be solved with $[H^+] = (K_aC_a)^{0.5}$
formic acid	1.8×10^{-4}	1×10^{-7}M	
Hydrocyanic acid	5×10^{-10}	1 M	
Hydrocyanic acid	5×10^{-10}	1×10^{-7}M	
hydrogen peroxide	2.4×10^{-12}	1M	

14. What is the approximate pH of 2.4×10^{-8} M HNO_3? Hint: if you get a pH greater than 7 for a strong acid it will make your professor very sad. We will learn an exact solution later in the semester.