

## Chem 260 – Second Exam

On the following pages are six problems covering material in equilibrium chemistry. Read each problem carefully and think about how best to approach it before you begin work. If you aren't sure how to begin a problem, then move on; working on a new problem may stimulate an idea that helps you solve the more troublesome one. For problems requiring a written response, be sure that your answer directly and clearly answers the question. No brain dumps allowed! Generous partial credit is available, but only if you include sufficient work for evaluation.

When working equilibrium problems, be sure to clearly state and verify any assumptions.

Problem 1 \_\_\_\_/10

Problem 4 \_\_\_\_/20

Problem 2 \_\_\_\_/20

Problem 5 \_\_\_\_/20

Problem 3 \_\_\_\_/10

Problem 6 \_\_\_\_/20

Total\_\_\_\_\_

A few constants are given here:

$$d_{\text{H}_2\text{O}} = 1.00 \text{ g/mL}$$

$$S_{\text{H}_2\text{O}} = 4.184 \text{ J/g}\cdot^\circ\text{C}$$

$$R = 8.314 \text{ J/mol}_{\text{rxn}}\cdot\text{K} \quad F = 96,485 \text{ J/V}\cdot\text{mol e}^-$$

$$K_w = 1.00 \times 10^{-14}$$

**Problem 1.** In Michael Crichton's novel *The Andromeda Strain* a virus brought back to earth on a satellite proves fatal to anyone who comes in contact with it. There are two survivors in the town where the satellite lands: a wino and a crying baby. The scientists studying the virus discover that it can survive only within the normal pH range of blood, which is 7.35 to 7.45. Crying causes the concentration of  $\text{CO}_2(g)$  in the baby's lungs to decrease. Knowing that  $\text{CO}_2(g)$  and  $\text{H}_2\text{O}$  make  $\text{H}_2\text{CO}_3$ , was the baby saved by an increase or a decrease in the pH of his or her blood? Clearly explain your choice in two or three sentences. Include relevant equilibrium reactions in support of your answer.

**Problem 2.** The  $\text{pK}_a$  values for several weak acids are shown below; use this information to answer the following:

If you prepare equimolar solutions of these weak acids, which will produce the smallest pH? Defend your choice in one sentence.

weak acid	formula	$\text{pK}_a$
benzoic acid	$\text{C}_6\text{H}_5\text{COOH}$	4.20
benzylammonium ion	$\text{C}_6\text{H}_5\text{CH}_2\text{NH}_3^+$	9.35
chloroacetic acid	$\text{ClCH}_2\text{COOH}$	2.57
hydroxylamine hydrochloride	$\text{H}_2\text{NOH}\cdot\text{HCl}$	5.96
thioacetic acid	$\text{HSCH}_2\text{COOH}$	3.33

Which of the weak acids has the strongest conjugate weak base and what is that base's  $\text{K}_b$  value? Defend your choice in one sentence.

Will a solution of benzylammonium thioacetate be acidic, basic or neutral? Defend your choice in one or two sentences.

Write the  $\text{K}_a$  reaction for hydroxylamine hydrochloride.

**Problem 3.** The simplest amino acid is glycine, which has the formula  $\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$ . Glycine is a polyprotic weak acid with a  $K_a$  of  $4.47 \times 10^{-3}$  for the  $-\text{COOH}$  functional group and a  $K_b$  of  $6.03 \times 10^{-5}$  for the  $-\text{NH}_2$  functional group. When dissolved in water at a pH of 7, in which of the following forms will glycine be present:



Circle your choice and, in two to four sentences, clearly explain why your choice is correct. Your explanation must be grounded in equilibrium acid/base chemistry.

**Problem 4.** The base putrescine,  $\text{H}_2\text{N}(\text{CH}_2)_4\text{NH}_2$ , plays a key role in the formation of the neurotransmitter GABA. A solution prepared by adding 0.882 g of putrescine to 100.0 mL of water has a pH of 11.32. What is the value of  $K_{b1}$  for putrescine? Although putrescine is dibasic, only the first base dissociation affects the solution's pH.

**Problem 5.** In lab you standardized a solution of NaOH by titrating it against a solution containing the weak acid potassium hydrogen phthalate,  $\text{KC}_8\text{H}_5\text{O}_4$ , which also is known as KHP. Suppose that you dissolve 0.312 g of KHP in 51.2 mL of water. What is the pH of this solution? The  $\text{pK}_a$  for KHP is 5.408.

**Problem 6.** Suppose that you need to prepare a buffer with a pH of 5.00. You already have 750 mL of a buffer that is 0.15 M in  $\text{CH}_3\text{COOH}$  and 0.50 M in  $\text{CH}_3\text{COO}^-$ . You also have access to 6.0 M HCl and 6.0 M NaOH. Clearly explain how you will prepare this buffer? The  $\text{pK}_a$  of  $\text{CH}_3\text{COOH}$  is 4.76.