

β

Name Key
(Please print family name last; e.g., Robert Boyle)

UMB Student Number _____

Chem 116 - Section 1
Hour Examination III
May 11, 2007

This test consists of seven (7) pages, including this cover page, a table of conjugate acid-base pairs with K_a values, and a periodic table. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one. **Feel free to detach the acid-base table and/or periodic table to use for reference or scratch paper.**

Give all numerical answers to the proper number of significant figures.

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

DO NOT WRITE BELOW THIS LINE

1.

2.

3.

4 a - e

4 f & g
+ bonus

TOTAL

β

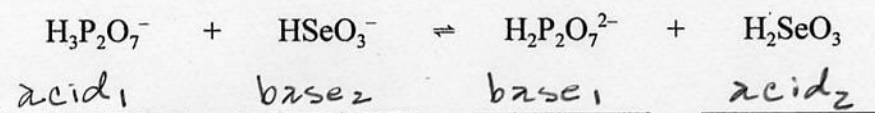
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1. (12 points; 3 points each part) Complete the following table by calculating the missing entries and indicating whether the solution is acidic or basic.

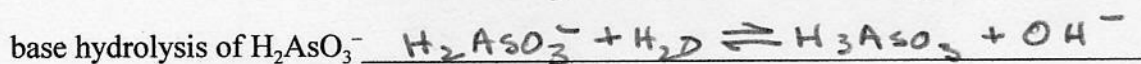
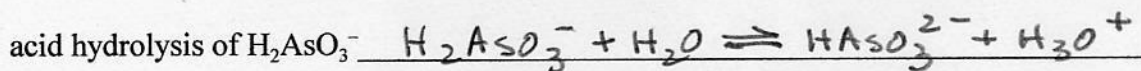
$[\text{H}_3\text{O}^+]$	$[\text{OH}^-]$	pH	pOH	acidic/basic?
1.3×10^{-6}	$7.7 \times 10^{-9} \text{ M}$	5.89	8.11	acidic

2. (32 points; 4 points each part) Fill in the blanks.

- a. For the following reaction, label the conjugate acid-base pairs (i.e., acid₁/base₁; acid₂/base₂).



- b. Write a balanced chemical equation for each of the following equilibria:



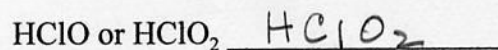
- c. Using data from the attached Table of Conjugate Acid-Base Pairs, what is the value of K_b for the oxalate ion, $\text{C}_2\text{O}_4^{2-}$?

$$K_b = \underline{1.56 \times 10^{-10}}$$

- d. Refer to the Table of Conjugate Acid-Base Pairs. Which one of the following solutions when added in excess to a solution containing 1.0 mmol $\text{Na}_3\text{PO}_4(\text{aq})$ would produce 1.0 mmol H_2PO_4^- ion in solution: $\text{HOCl}(\text{aq})$, $\text{Fe}(\text{NO}_3)_3(\text{aq})$, $\text{NH}_4\text{NO}_3(\text{aq})$?

Answer: $\text{Fe}(\text{NO}_3)_3$

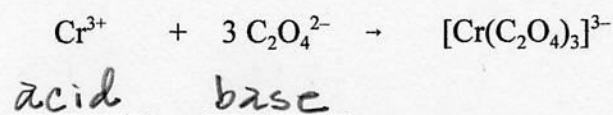
- e. For each of the following pairs, which one is the stronger acid?



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- f. Identify the Lewis acid and Lewis base in the following reaction



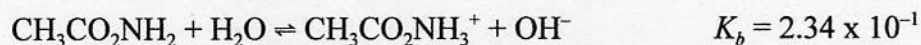
- g. The base B has
- $K_b = 1.0 \times 10^{-6}$
- . What is the pH of a buffer solution prepared by mixing 1.0 mol B with 1.0 mol of the salt HBCl in enough water to make a liter of solution?

$$\text{pH} = \underline{8.00}$$

- k. Indicate whether 0.10 M aqueous solutions of each of the following solutions would have a pH > 7.0, pH < 7.0, or pH ≈ 7.0:



3. (12 points) The following two problems pertain to a solution of the base acetamide, whose hydrolysis reaction and
- K_b
- are



- a. (8 points) Calculate the concentration of hydroxide ion,
- $[\text{OH}^-]$
- , in a 0.120 M solution of acetamide.

$$K_b = \frac{[\text{OH}^-]^2}{0.120 - [\text{OH}^-]} = 0.234$$

$$[\text{OH}^-]^2 + 0.234[\text{OH}^-] - 0.02808 = 0$$

$$[\text{OH}^-] = 0.08737 \text{ M} = 0.0874 \text{ M}$$

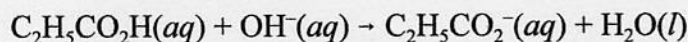
- b. (4 points) Based on your answer to part a, what is the percent hydrolysis of acetamide in this solution?

$$\% \text{ hydrolysis} = \frac{0.08737}{0.120} \times 100\% = 72.8\%$$

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4. (44 points) $K_a = 1.34 \times 10^{-5}$ for propionic acid, $C_2H_5CO_2H$. Consider the titration of 25.0 mL of 0.160 M $C_2H_5CO_2H$ solution (the analyte), with 0.100 M $NaOH(aq)$ solution (the titrant):



- a. (4 points) How many milliliters of 0.100 M $NaOH(aq)$ solution must be added to reach the equivalence point?

$$V_b = \frac{M_a V_a}{M_b} = \frac{(0.160 M)(25.0 mL)}{0.100 M} = 40.0 mL$$

- b. (2 points) What is the total volume in the solution at the equivalence point? 65.0 mL
- c. (2 points) How many millimoles of $C_2H_5CO_2H$ are present in the analyte sample before any titrant has been added?

$$\text{millimoles } C_2H_5CO_2H = \underline{4.00}$$

- d. (6 points) What is the initial pH of the $C_2H_5CO_2H$ solution, before adding any titrant?

$$[H_3O^+] = \sqrt{(0.160)(1.34 \times 10^{-5})} = \sqrt{2.144 \times 10^{-6}}$$

$$= 1.46 \times 10^{-3} M$$

$$pH = 2.834$$

- e. (6 points) What is the pH of the resulting solution after adding 20.0 mL of 0.100 M $NaOH(aq)$ solution? [Hint: How far along in the titration is this?]

$$\text{Half-titration point} \Rightarrow pH = pK_a$$

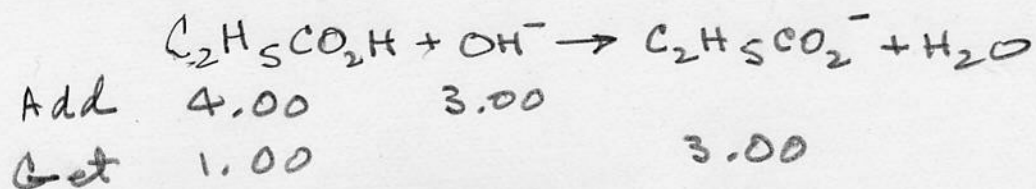
$$pH = -\log(1.34 \times 10^{-5}) = 4.873$$

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- f. (10 points) What is the pH of the resulting solution after adding 30.0 mL of 0.100 M NaOH(aq) solution?



$$K_a = \frac{[\text{H}_3\text{O}^+](3.00)}{1.00} = 1.34 \times 10^{-5}$$

$$[\text{H}_3\text{O}^+] = \frac{(1.00)(1.34 \times 10^{-5})}{3.00} = 4.47 \times 10^{-6} \text{ M}$$

$$\text{pH} = 5.350$$

- g. (14 points) What is the pH at the equivalence point?

$$K_b = \frac{1.00 \times 10^{-14}}{1.34 \times 10^{-5}} = 7.46 \times 10^{-10}$$

$$C_{A^-} = \frac{4.00 \text{ mmol}}{65.0 \text{ mL}} = 6.15 \times 10^{-2}$$

$$\begin{aligned} [\text{OH}^-] &= \sqrt{(7.46 \times 10^{-10})(6.15 \times 10^{-2})} = \sqrt{4.59 \times 10^{-11}} \\ &= 6.78 \times 10^{-6} \text{ M} \end{aligned}$$

$$\text{pOH} = 5.169$$

$$\text{pH} = 8.831$$

- BONUS (5 points) What is the pH of the solution after the addition of 50.0 mL of 0.100 M NaOH solution?

$$\text{mmol OH}^- = (50.0 \text{ mL})(0.100 \text{ M}) = 1.00 \text{ mmol}$$

$$V = 75.0 \text{ mL}$$

$$[\text{OH}^-] = \frac{1.00 \text{ mmol}}{75.0 \text{ mL}} = 1.33 \times 10^{-2} \text{ M} \Rightarrow \text{pOH} = 1.875$$

$$\text{pH} = 12.125$$