Name Key
(Please Print)

Chem 104 - Section 1
Sample Test 3

This test consists of five (5) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one.

A separate table of conjugate acid-base pairs with K_a values and a periodic table will be distributed with this test. Use them for any problems to which they might pertain. If you mark on either of these, please throw them away after the test. Otherwise, return them for reuse later.

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

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

DO NOT WRITE BELOW THIS LINE

This is a copy of a typical third test in Chem 104. Your test will be different. This test is being posted to give you a sense of the format, style, scope, and level of a typical test on this material. This test may have questions on topics that will not be covered on the test you take. Moreover, your test may have questions on topics that are not covered on this test. Posting this test in no way limits the format, style, scope, or level of the test that you will take. **Do not limit your preparation to the material on this sample test.**

Name Key

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.

$[H_3O^+]$	$[OH^-]$	pH	pOH	acidic or basic?
1.8×10^{-9}	5.5×10^{-6} M	8.74	5.26	basic

2. (44 points; 4 points each part) Fill in the blanks.

a. For the following reaction, label the conjugate acid-base pairs (i.e., $acid_1/base_1$; $acid_2/base_2$).

$$HSeO_4^{2-} + HCO_2^- \rightleftharpoons SeO_4^{2-} + HCO_2H$$

acid$_1$ base$_2$ base$_1$ acid$_2$

b. A solution of pure sodium selenate in water, $Na_2SeO_4(aq)$, would be basic (acidic/neutral/basic).

c. Judging by the Table of Conjugate Acid-Base Pairs, the aqueous equilibrium

$$H_2S(aq) + C_2O_4^{2-}(aq) \rightleftharpoons HS^-(aq) + HC_2O_4^-(aq)$$

lies to the left (left/right).

d. Judging by the Table of Conjugate Acid-Base Pairs, the aqueous equilibrium

$$H_2PO_4^-(aq) + NH_3(aq) \rightleftharpoons HPO_4^{2-}(aq) + NH_4^+(aq)$$

lies to the right (left/right).

e. Consider the ion $H_2AsO_4^-$ (not listed in the Table of Conjugate Acid-Base Pairs). The formula for its conjugate acid is H_3AsO_4, and the formula for its conjugate base is $HAsO_4^{2-}$.

(Be sure the charges, if any, are correct on both species.)

Name Key

f. On the lines below, briefly describe the two situations under which any buffer with a high buffer capacity resists significantly changing its pH.

① Moderate dilution.

② Addition of small amounts of H_3O^+ or OH^-.

g. Identify the *stronger acid* between the following pairs.

$HClO_2$ vs. HOCl $HClO_2$ $CH_3CH_2CO_2H$ vs. $Cl_3CCH_2CO_2H$ $Cl_3CCH_2CO_2H$

h. Identify the Lewis acid and Lewis base in the following reaction:

$$Ni^{2+}(aq) + 4NH_3(aq) \rightleftharpoons Ni(NH_3)_4^{2+}(aq)$$

acid base

i. For the weak acid HOBr, $K_a = 2.06 \times 10^{-9}$. The conjugate base of HOBr is OBr^-, which has a K_b value of 4.85×10^{-6}.

j. Without using your calculator, what is the pH of each of the following solutions of nitric acid, $HNO_3(aq)$? [Don't make this hard, but think before you answer.]

1.0×10^{-3} M $HNO_3(aq)$ 3.00 1.0×10^{-10} M $HNO_3(aq)$ 7.00 (extremely dilute)

k. What is the pH of a solution that is 0.10 M in hypobromous acid (HOBr, $K_a = 2.06 \times 10^{-9}$) and 0.10 M in hydrochloric acid, HCl(*aq*)? [Again, don't make this hard, but think before you answer.]

Only HCl makes a significant contribution to total $[H_3O^+]$.

Answer 1.00

Name Key

3. (22 points) All of the following questions refer to the titration of 20.0 mL of 0.150 M HCl(*aq*) solution (the analyte) with 0.0750 M NaOH(*aq*) solution (the titrant).

a. (4 points) How many milliliters of 0.0750 M NaOH(*aq*) solution must be added to reach the equivalence point?

$$V_{NaOH} = \frac{(20.0\,mL)(0.150\,M)}{0.0750\,M} = 40.0\,mL$$

b. (3 points) How many millimoles of H_3O^+ ion are present in the analyte sample before any titrant has been added?

$$mmol\ H_3O^+ = (20.0\,mL)(0.150\,M) = 3.00\,mmol$$

c. (12 points) What is the pH of the resulting solution after adding 24.0 mL of 0.0750 M NaOH(*aq*) solution?

$$mmol\ OH^-\ added = (24.0\,mL)(0.0750\,M) = 1.80\,mmol$$

$$H_3O^+ + OH^- \longrightarrow 2H_2O$$

	H_3O^+	OH^-
Add	3.00	1.80
Get	1.20	~0

$$V = (20.0 + 24.0)\,mL = 44.0\,mL$$

$$[H_3O^+] = \frac{1.20\,mmol}{44.0\,mL} = 2.72_{72..} \times 10^{-2}$$

$$pH = 1.56$$

d. (3 points) What is the pH at the equivalence point? 7.00 (Always for a strong acid-strong base titration, but never for a weak acid or weak base titration.)

Name Key

4. (22 points) Do both parts.

a. (10 points) Benzoic acid, $C_6H_5CO_2H$, has a K_a of 6.5×10^{-5}. Calculate the concentrations of $H_3O^+(aq)$, $C_6H_5CO_2^-(aq)$, and $C_6H_5CO_2H(aq)$ in a 0.12 M benzoic acid solution. Summarize your results on the lines below, **but be sure to show work leading to your answers.** [For simplicity in writing, represent benzoic acid as HBz and the benzoate ion as Bz^-.]

$C_{HBz} >> K_a \Rightarrow$ Use Assumptions I & II.

$[H_3O^+] = \sqrt{(0.12)(6.5\times10^{-5})} = \sqrt{7.8\times10^{-6}}$

$= 2.8\times10^{-3} = [Bz^-]$

$[H_3O^+] = \underline{2.8\times10^{-3}}$ M $\quad [Bz^-] = \underline{2.8\times10^{-3}}$ M $\quad [HBz] = \underline{0.12}$ M

b. (12 points) What is the pH of the resulting solution made by adding 23 g of sodium benzoate, $NaC_6H_5CO_2$ (f.w. = 144 u), to 1.0 L of 0.12 M benzoic acid?

mol HBz = (1.0 L)(0.12 M) = 0.12 mol

mol Bz^- = $(23\text{ g})\left(\frac{\text{mol}}{144\text{ g}}\right)$ = 0.16 mol

$K_a = \frac{[H_3O^+][Bz^-]}{[HBz]} = 6.5\times10^{-5} = \frac{[H_3O^+](0.16)}{0.12}$

$[H_3O^+] = \frac{(0.12)(6.5\times10^{-5})}{0.16} = 4.875\times10^{-5} = 4.9\times10^{-5}$

pH = 4.31