CHEMISTRY 104-4
Prof. Treichel
April 18, 2006

NAME Key

Section _____ T.A._____

EXAM 3

1. This exam has 8 pages. If a page is missing, take the exam to a proctor immediately.

2. PRINT your name now at the top of this page and your name or initials at the top of the remaining pages.

3. DETACH THE LAST 2 PAGES (TABLES OF K_a, K_b, and K_{sp} VALUES) FROM THE END OF THE EXAM.

4. **Work must be shown for mathematical problems.** If a correct answer is given without any work, points may be deducted.

5. **Whenever appropriate, include units with numerical answers. All answers should have the correct number of significant figures.**

6. Points for each question are indicated.

7. The exam should be completed in 75 minutes. Budget your time for each question. Check your work after completing the exam.

Page 2		/20
Page 3		/20
Page 4		/12
Page 5		/20
Page 6		~~/18~~
Total		~~/100~~ 82

Chemistry 104-4, third exam Name or initials _____

Part I. (26 Questions x 2 = 52 pts) Short answers. You will need to use K_a and K_{sp} tables at the end of the exam to answer some of these questions.

1) What is the pH at the equivalence point of a titration of 50.0 mL of 0.0500 M HNO_3 with 25 mL of 0.100 M KOH? pH 7.00

2) What is the pH of a 2.0×10^{-2} M solution of NaOH? pH 12.31

3) What is the conjugate acid of HCO_3^-? conj. Acid H_2CO_3

4) What is the conjugate base of H_2O? conj. base OH^-

5), 6) Which solution has the highest pH (most basic) and which has the lowest pH, among those listed below:
0.1 M F^- (aq) 0.1 M CO_3^{2-} (aq) 0.1 M Cl^- (aq) 0.1 M CN^- (aq)

5) highest pH 0.1 M CO_3^{2-}

6) lowest pH 0.1 M Cl^-

7) What information do you need to calculate the pH at the half neutralization point in a titration of 0.20 M HF with 0.10 M NaOH? Ka (or pKa) for HF

8) Calculate the value of K_b for the butanoate ion. The value of K_a for butanoic acid is $K_a = 1.52 \times 10^{-5}$

$K_b = \frac{K_w}{K_a}$

K_b 6.6×10^{-10}

9) What is the pH of a buffer solution made up of equimolar amounts of butanoic acid and sodium butanoate? pH = 4.82

$pH = pK_a$

10) Which solution among those listed below has the lowest conductivity?
0.10 M HOCl
0.10 M H_2SO_4
0.10 M H_3PO_4
0.10 M HCO_2H

lowest conductivity 0.10 M HOCl

11) Is the reaction of NaF and HCO_3^- product- or reactant-favored?

$F^-(aq) + HCO_3^-(aq) \rightleftharpoons HF(aq) + CO_3^{2-}(aq)$

reactant favored

(HCO_3^- is a weaker acid than HF)

12) What will happen to the pH (lg. increase, small increase, no change, small decrease. large decrease) if solid NaF is NaF is added to a HF/NaF buffer?

small increase

13) A solution of containing 0.10 M $HClO_2$ is 30% ionized. Calculate its pH.

1.52

$[H^+] = (0.30 \times 0.1) = 0.030$

14) The indicator Eriochrome Black T is red at pH = 5 and blue at pH = 7. It is a weak acid, what is its K_{ind} value?

$\sim 10^{-6}$

15) Write the chemical equation for the reaction that occurs when NaOH is added to a $H_2PO_4^-/HPO_4^{2-}$ buffer solution.

$H_2PO_4^- + OH^- \longrightarrow HPO_4^{2-} + H_2O$

16) Write the net ionic equation for the reaction between nitric acid and sodium fluoride.

$H^+ + F^- \longrightarrow HF$

17) Is the reaction in Q16 product- or reactant-favored?

product favored

18) Give the formulas for two insoluble salts of Pb^{2+} that will not dissolve in strong acid (choose from K_{sp} table)

$PbCl_2$, $PbBr_2$, PbI_2 and $PbSO_4$

19) Which of the silver salts listed below has the highest solubility?

AgI AgBr AgSCN Ag_2CO_3

Ag_2CO_3

20) In which of the following will AgCl be most and least soluble?

pure water 0.01 M NaCl 0.10 M HCl 1.0 M NH_3

most soluble in 1.0 M NH_3

least soluble in 0.1 M HCl

21) Write the net ionic equation for the reaction that occurs when solid $Ca_3(PO_4)_2(s)$ dissolves in excess strong acid.

$Ca_3(PO_4)_2 + 6H^+ \longrightarrow 3Ca^{2+} + 2\ H_3PO_4$

22) What is the formula for the complex ion that is formed when AgCl dissolves in $NH_3(aq)$?

$Ag(NH_3)_2^+$

23) Calculate the solubility of AgBr from its K_{sp} (6.5×10^{-13}). 8.0×10^{-7} mol/L

$x^2 = K_{sp}$

24) Calculate the solubility of AgBr in 0.10 M NaBr. 6.5×10^{-12} mol/L

$K_{sp} = [x][0.10]$

25) You mix 0.0405 g (2.38×10^{-4} mol) of $AgNO_3(s)$ and 0.0034 g (5.81×10^{-5} mol) NaCl(s) in enough water to give 1.000 L of solution. Calculate Q and determine whether precipitation of AgCl ($K_{sp} = 1.80 \times 10^{-10}$) will occur.

$[Ag^+][Cl^-] = Q$

$[2.38 \times 10^{-4}][5.81 \times 10^{-5}] = 1.4 \times 10^{-8}$

$Q = 1.4 \times 10^{-8}$

Precipitate forms? (Yes) No

26) Silver ion forms a complex ion with cyanide ion with the formula $Ag(CN)_2^-$. You want to do a calculation to predict whether the following reaction $AgCN(s) + CN^-(aq) \rightleftharpoons Ag(CN)_2^-(aq)$ is product- or reactant favored. What information should you look up?

K_{sp} for AgCN

K_f for $Ag(CN)_2^-$

Chemistry 104-4, third exam Name or initials _____

1. (10 pts) In lab, you have available the following: solid NaH_2PO_4, solid Na_2HPO_4, and water. You want to prepare 500. mL of a buffer solution that has a pH of 7.10 and you want the molarities of acid and base in the buffer to be near 0.5 molar. You need to weigh out specific amounts of the two ionic compounds, put them in a 500. mL volumetric flask, and add water.

a) (7) Calculate the molar ratio of the two salts that will be required to produce this buffer solution. K_2 for $H_2PO_4^-$ = 6.2×10^{-8}

$$pH = pKa + \log \frac{base}{acid}$$

$$7.1 = 7.21 + \log \frac{b}{a}$$

$$\frac{b}{a} = 0.78$$

$[HPO_4^{2-}]/[H_2PO_4^-]$ = 0.78

b) (3) You have decided to use 30. g of NaH_2PO_4 (0.25 mol). How many grams of Na_2HPO_4 do you need to weigh out? (142 g/mol for Na_2HPO_4)

$$0.25 \text{ mol } H_2PO_4^- \left(\frac{0.77 \text{ mol } HPO_4^{2-}}{1 \text{ mol } H_2PO_4^-}\right)\left(\frac{142 \text{ g } Na_2HPO_4}{1 \text{ mol}}\right)$$

$$= 28 \text{ g}$$

g Na_2HPO_4 28 g

2. (10 pts) Calcium hydroxide is a slightly soluble base ($K_{sp} = 5.5 \times 10^{-5}$). A 1.0 g sample of solid $Ca(OH)_2$ is shaken with 500. mL of water.

a) (6) Calculate the mass (grams) of $Ca(OH)_2$ that dissolves. (It is necessary that some solid $(Ca(OH)_2$ remains so that the equilibrium calculation in part b can be carried out.)

calc molar solubility (=x)

$$K_{sp} = [Ca^{2+}][OH^-]^2$$

$$5.5 \times 10^{-5} = (x)(2x)^2$$

$$x = 2.4 \times 10^{-2} \text{ mol/L}$$

mass dissolving

$$2.4 \times 10^{-2} \frac{\text{mol}}{\text{L}} \left(\frac{74 \text{ g}}{1 \text{ mol}}\right)(0.5 \text{ L}) = 0.89 \text{ g}$$

g $Ca(OH)_2$ that dissolve 0.89 g

b) (4) What is the pH of the saturated $Ca(OH)_2$ solution formed in this process?

sol. = 2.4×10^{-2} M

$[OH^-] = 2 \times 2.4 \times 10^{-2} = 4.8 \times 10^{-2}$ M

pOH = 1.32

pH = 14 - 1.32

pH 12.68