CHEMISTRY 104-4
Prof. Treichel
April 18, 2006

NAME _____

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.

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Page 6		/18
Total		/100

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 _____

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

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

4) What is the conjugate base of H_2O? conj. base _____

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 _____

6) lowest pH _____

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? _____

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 _____

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

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

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

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

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? _____

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

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? _____

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

_____

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

_____

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

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

_____

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

AgI AgBr AgSCN 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 _____

least soluble _____

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

_____

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

_____

23) Calculate the solubility of AgBr from its K_{sp} (6.5×10^{-13}). _____

24) Calculate the solubility of AgBr in 0.10 M NaBr. _____

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.

Q = _____

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?

_____

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.

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

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?

g Na_2HPO_4 _____

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.)

g $Ca(OH)_2$ that dissolve _____

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

pH _____

Solubility Product Constants for Some Inorganic Compounds at 25 °C

Table 18A • **Solubility Product Constants (25 °C)**

Cation	Compound	K_{sp}	Cation	Compound	K_{sp}
Ba^{2+}	*$BaCrO_4$	1.2×10^{-10}	Mg^{2+}	$MgCO_3$	6.8×10^{-6}
	$BaCO_3$	2.6×10^{-9}		MgF_2	5.2×10^{-11}
	BaF_2	1.8×10^{-7}		$Mg(OH)_2$	5.6×10^{-12}
	*$BaSO_4$	1.1×10^{-10}			
			Mn^{2+}	$MnCO_3$	2.3×10^{-11}
Ca^{2+}	$CaCO_3$ (calcite)	3.4×10^{-9}		*$Mn(OH)_2$	1.9×10^{-13}
	*CaF_2	5.3×10^{-11}			
	*$Ca(OH)_2$	5.5×10^{-5}	Hg_2^{2+}	*Hg_2Br_2	6.4×10^{-23}
	$CaSO_4$	4.9×10^{-5}		Hg_2Cl_2	1.4×10^{-18}
				*Hg_2I_2	2.9×10^{-29}
$Cu^{+,2+}$	CuBr	6.3×10^{-9}		Hg_2SO_4	6.5×10^{-7}
	CuI	1.3×10^{-12}			
	$Cu(OH)_2$	2.2×10^{-20}	Ni^{2+}	$NiCO_3$	1.4×10^{-7}
	CuSCN	1.8×10^{-13}		$Ni(OH)_2$	5.5×10^{-16}
Au^+	AuCl	2.0×10^{-13}	Ag^+	*AgBr	5.4×10^{-13}
				*$AgBrO_3$	5.4×10^{-5}
Fe^{2+}	$FeCO_3$	3.1×10^{-11}		$AgCH_3CO_2$	1.9×10^{-3}
	$Fe(OH)_2$	4.9×10^{-17}		AgCN	6.0×10^{-17}
				Ag_2CO_3	8.5×10^{-12}
Pb^{2+}	$PbBr_2$	6.6×10^{-6}		*$Ag_2C_2O_4$	5.4×10^{-12}
	$PbCO_3$	7.4×10^{-14}		*AgCl	1.8×10^{-10}
	$PbCl_2$	1.7×10^{-5}		Ag_2CrO_4	1.1×10^{-12}
	$PbCrO_4$	2.8×10^{-13}		*AgI	8.5×10^{-17}
	PbF_2	3.3×10^{-8}		AgSCN	1.0×10^{-12}
	PbI_2	9.8×10^{-9}		*Ag_2SO_4	1.2×10^{-5}
	$Pb(OH)_2$	1.4×10^{-15}			
	$PbSO_4$	2.5×10^{-8}			

(continued)

Table 18B • **K_{spa} Values* for Some Metal Sulfides (25 °C)**

Substance	K_{spa}
HgS (red)	4×10^{-54}
HgS (black)	2×10^{-53}
Ag_2S	6×10^{-51}
CuS	6×10^{-37}
PbS	3×10^{-28}
CdS	8×10^{-28}
SnS	1×10^{-26}
FeS	6×10^{-19}

Cation	Compound	K_{sp}	Cation	Compound	K_{sp}
Sr^{2+}	$SrCO_3$	5.6×10^{-10}	Zn^{2+}	$Zn(OH)_2$	3×10^{-17}
	SrF_2	4.3×10^{-9}		$Zn(CN)_2$	8.0×10^{-12}
	$SrSO_4$	3.4×10^{-7}			
Tl^+	TlBr	3.7×10^{-6}			
	TlCl	1.9×10^{-4}			
	TlI	5.5×10^{-8}			

Table 17.5 • Ionization Constants for Some Acids and Their Conjugate Bases

Acid Name	Acid	K_a	Base	K_b	Base Name
Perchloric acid	$HClO_4$	large	ClO_4^-	very small	perchlorate ion
Sulfuric acid	H_2SO_4	large	HSO_4^-	very small	hydrogen sulfate ion
Hydrochloric acid	HCl	large	Cl^-	very small	chloride ion
Nitric acid	HNO_3	large	NO_3^-	very small	nitrate ion
Hydronium ion	H_3O^+	1.0	H_2O	1.0×10^{-14}	water
Sulfurous acid	H_2SO_3	1.2×10^{-2}	HSO_3^-	8.3×10^{-13}	hydrogen sulfite ion
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}	SO_4^{2-}	8.3×10^{-13}	sulfate ion
Phosphoric acid	H_3PO_4	7.5×10^{-3}	$H_2PO_4^-$	1.3×10^{-12}	dihydrogen phosphate ion
Hexaaquairon(III) ion	$Fe(H_2O)_6^{3+}$	6.3×10^{-3}	$Fe(H_2O)_5OH^{2+}$	1.6×10^{-12}	pentaaquahydroxoiron(III) ion
Hydrofluoric acid	HF	7.2×10^{-4}	F^-	1.4×10^{-11}	fluoride ion
Nitrous acid	HNO_2	4.5×10^{-4}	NO_2^-	2.2×10^{-11}	nitrite ion
Formic acid	HCO_2H	1.8×10^{-4}	HCO_2^-	5.6×10^{-11}	formate ion
Benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}	$C_6H_5CO_2^-$	1.6×10^{-10}	benzoate ion
Acetic acid	CH_3CO_2H	1.8×10^{-5}	$CH_3CO_2^-$	5.6×10^{-10}	acetate ion
Propanoic acid	$CH_3CH_2CO_2H$	1.3×10^{-5}	$CH_3CH_2CO_2^-$	7.7×10^{-10}	propanoate ion
Hexaaquaaluminum ion	$Al(H_2O)_6^{3+}$	7.9×10^{-6}	$Al(H_2O)_5OH^{2+}$	1.3×10^{-9}	pentaaquahydroxoaluminum ion
Carbonic acid	H_2CO_3	4.2×10^{-7}	HCO_3^-	2.4×10^{-8}	hydrogen carbonate ion
Hexaaquacopper(II) ion	$Cu(H_2O)_6^{2+}$	1.6×10^{-7}	$Cu(H_2O)_5OH^+$	6.25×10^{-8}	pentaaquahydroxocopper(II) ion
Hydrogen sulfide	H_2S	1×10^{-7}	HS^-	1×10^{-7}	hydrogen sulfide ion
Dihydrogen phosphate ion	$H_2PO_4^-$	6.2×10^{-8}	HPO_4^{2-}	1.6×10^{-7}	hydrogen phosphate ion
Hydrogen sulfite ion	HSO_3^-	6.2×10^{-8}	SO_3^{2-}	1.6×10^{-7}	sulfite ion
Hypochlorous acid	HClO	3.5×10^{-8}	ClO^-	2.9×10^{-7}	hypochlorite ion
Hexaaqualead(II) ion	$Pb(H_2O)_6^{2+}$	1.5×10^{-8}	$Pb(H_2O)_5OH^+$	6.7×10^{-7}	pentaaquahydroxolead(II) ion
Hexaaquacobalt(II) ion	$Co(H_2O)_6^{2+}$	1.3×10^{-9}	$Co(H_2O)_5OH^+$	7.7×10^{-6}	pentaaquahydroxocobalt(II) ion
Boric acid	$B(OH)_3(H_2O)$	7.3×10^{-10}	$B(OH)_4^-$	1.4×10^{-5}	tetrahydroxoborate ion
Ammonium ion	NH_4^+	5.6×10^{-10}	NH_3	1.8×10^{-5}	ammonia
Hydrocyanic acid	HCN	4.0×10^{-10}	CN^-	2.5×10^{-5}	cyanide ion
Hexaaquairon(II) ion	$Fe(H_2O)_6^{2+}$	3.2×10^{-10}	$Fe(H_2O)_5OH^+$	3.1×10^{-5}	pentaaquahydroxoiron(II) ion
Hydrogen carbonate ion	HCO_3^-	4.8×10^{-11}	CO_3^{2-}	2.1×10^{-4}	carbonate ion
Hexaaquanickel(II) ion	$Ni(H_2O)_6^{2+}$	2.5×10^{-11}	$Ni(H_2O)_5OH^+$	4.0×10^{-4}	pentaaquahydroxonickel(II) ion
Hydrogen phosphate ion	HPO_4^{2-}	3.6×10^{-13}	PO_4^{3-}	2.8×10^{-2}	phosphate ion
Water	H_2O	1.0×10^{-14}	OH^-	1.0	hydroxide ion
Hydrogen sulfide ion*	HS^-	1×10^{-19}	S^{2-}	1×10^5	sulfide ion
Ethanol	C_2H_5OH	very small	$C_2H_5O^-$	large	ethoxide ion
Ammonia	NH_3	very small	NH_2^-	large	amide ion
Hydrogen	H_2	very small	H^-	large	hydride ion

Increasing Acid Strength ↑

Increasing Base Strength ↓

*The values of K_a for HS^- and K_b for S^{2-} are estimates.