CHM 1410-001
Spring 2005
Test 3 (100 pts)

Name (Please Print) ____________________________

$K_w = [H^+][OH^-]$ pH = -log[H^+] pAnything = -log(Anything) pH + pOH = 14
$K_aK_b = K_w$ pH = pK_a + log [base]/[acid]

Multiple Choice – 4 pts. each

1. In the reaction $HSO_4^-(aq) + OH^-(aq) \leftrightharpoons SO_4^{2-}(aq) + H_2O(l)$, the conjugate acid-base pairs are

   pair 1 *pair 2*
   (A) HSO_4^- and SO_4^{2-}; H_2O and OH^-.
   B. HSO_4^- and H_3O^+; SO_4^{2-} and OH^-.
   C. HSO_4^- and OH^-; SO_4^{2-} and H_2O.
   D. HSO_4^- and H_2O; OH^- and SO_4^{2-}.
   E. HSO_4^- and OH^-; SO_4^{2-} and H_3O^+.

2. For HNO_2, $K_a = 4.5 \times 10^{-4}$. An aqueous solution of $NaNO_2$ therefore would be

   A. neutral (B.) basic C. acidic

3. A titration of an acid and base to the equivalence point results in a noticeably acidic solution. It is likely this titration involves

   (A.) a strong acid and a weak base.
   B. a weak acid and a strong base.
   C. a weak acid and a weak base (where K_a equals K_b).
   D. a strong acid and a strong base.

4. What is the pH at the equivalence point in the titration of 100 mL of 0.10 M HCl with 0.10 M NaOH?

   A. 1.0 B. 6.0 (C.) 7.0 D. 8.0 E. 13.0

5. Which of the following would decrease the molar solubility of PbI_2?

   A. Lowering the pH of the solution
   B. Adding a solution of $Ba(NO_3)_2$
   (C.) Adding a solution of KI
   D. None of the above—the K_{sp} of a compound is constant at constant temperature.

6. Which of the following statement is true for a 0.10 M solution of a weak acid HA?

A. The pH is 1.00
B. The $[H^+] = 0.10$ M
C. The $[HA] = 0.10$ M
(D.) The pH is > 1.00
E. None of the above

7. Which of the following accurately reflects the K_{sp} expression for a saturated CaF_2 solution ($CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq)$)

A. $K_{sp} = [Ca^{2+}][F^-]$
B. $K_{sp} = [Ca^{2+}][F^-]/[CaF_2]$
C. $K_{sp} = [CaF_2]/[Ca^{2+}][F^-]^2$
(D.) $K_{sp} = [Ca^{2+}][F^-]^2$
E. $K_{sp} = 1/[Ca^{2+}][F^-]^2$

Use this information to answer the following two questions.
Given the following K_a values: HF = 7.1×10^{-4}, $HNO_2 = 4.5 \times 10^{-4}$, $CH_3COOH = 1.8 \times 10^{-5}$, HCN = 4.9×10^{-10}

8. Which is the correct order of acid strength from *most* acidic to *least* acidic.

A. HCN > CH_3COOH > HNO_2 > HF
(B.) HF > HNO_2 > CH_3COOH > HCN
C. HNO_2 > CH_3COOH > HCN > HF
D. CH_3COOH > HCN > HF > HNO_2
E. HCN > HF > HNO_2 > CH_3COOH

9. Which is the correct order of base strength from *most* basic to *least* basic.

(A.) CN^- > CH_3COO^- > NO_2^- > F^-
B. F^- > NO_2^- > CH_3COO^- > CN^-
C. NO_2^- > CH_3COO^- > CN^- > F^-
D. CH_3COO^- > CN^- > F^- > NO_2^-
E. CN^- > F^- > NO_2^- > CH_3COO^-

Problems

1.(10) Calculate the pH of a 2.6×10^{-2} M KOH solution.

$KOH \rightarrow K^+ + {}^-OH \quad [{}^-OH] = 2.6 \times 10^{-2}$

$pOH = -\log(2.6 \times 10^{-2}) = 1.6$

$pH + pOH = 14$

$pH + 1.6 = 14$

$pH = 14 - 1.6 = 12.4$

2.(10) Calculate the pH of a 0.25 M solution of ascorbic acid (Vitamin C, $K_a = 8.0 \times 10^{-5}$)

	HA	⇌ H^+	+ A^-
I	0.25	0	0
C	−x	+x	+x
E	0.25−x	x	x

$K_a = 8.0 \times 10^{-5} = \frac{[H^+][A^-]}{[HA]} = \frac{(x)(x)}{0.25-x}$

if $x \ll 0.25$ then $8.0 \times 10^{-5} = \frac{x^2}{0.25}$

$(8.0 \times 10^{-5})(0.25) = x^2$

$\frac{4.47 \times 10^{-3}}{0.25} \times 100 = 1.8\%$ ✓

$4.47 \times 10^{-3} = x = [H^+]$

$pH = -\log[H^+] = -\log(4.47 \times 10^{-3})$

$pH = 2.35$

3.(10) Calculate the pH of a 0.35 M solution of caffeine ($K_b = 4.1 \times 10^{-4}$)

$B + H_2O \rightleftharpoons BH^+ + {}^-OH$ (B = caffeine)

	B	H_2O	BH^+	^-OH
I	0.35	-	0	0
C	-x	-	+x	+x
E	0.35-x	-	x	x

$K_b = 4.1 \times 10^{-4} = \frac{[BH^+][^-OH]}{[B]} = \frac{(x)(x)}{0.35-x}$

if $x \ll 0.35$ then $4.1 \times 10^{-4} = \frac{x^2}{0.35}$

$(4.1 \times 10^{-4})(0.35) = x^2$

$1.20 \times 10^{-2} = x = [^-OH]$ $\frac{1.20 \times 10^{-2}}{0.35} \times 100 \approx 3\%$ ✓

$pOH = -\log(1.20 \times 10^{-2}) = 1.9$

$pH = 14 - pOH$

$pH = 14 - 1.9 = 12.1$

4.(10) In pills, Vitamin C is often administered as sodium ascorbate. Calculate the pH of a 0.50 M solution of sodium ascorbate (refer to question 2 for important information).

$K_a = 8.0 \times 10^{-5}$ $K_b = \frac{1 \times 10^{-14}}{8.0 \times 10^{-5}} = 1.25 \times 10^{-10}$

$NaA \rightarrow Na^+ + A^-$; $A^- + H_2O \rightleftharpoons HA + {}^-OH$

	A^-	H_2O	HA	^-OH
I	0.50	-	0	0
C	-x	-	+x	+x
E	0.50-x		x	x

$K_b = 1.25 \times 10^{-10} = \frac{(x)(x)}{0.50-x}$ if $x \ll 0.50$ then

$1.25 \times 10^{-10} = \frac{x^2}{0.50}$

$(1.25 \times 10^{-10})(0.50) = x^2$

$7.9 \times 10^{-6} = x = [^-OH]$ ✓

$pOH = -\log(7.9 \times 10^{-6}) = 5.1$

$pH = 14 - 5.1 = 8.9$

5.(14) Calculate the pH of a 1 liter solution which contains 0.25 M ascorbic acid and 0.50 M sodium ascorbate.

$pKa = -\log(8.0 \times 10^{-5}) = 4.10$

$pH = pKa + \log \frac{[\text{ascorbate}]}{[\text{ascorbic acid}]}$

$pH = 4.10 + \log \frac{(0.50)}{(0.25)}$

$pH = 4.10 + \log 2$

$pH = 4.40$

6.(10) The K_{sp} value for lead(II) iodide (PbF_2) is 4.1×10^{-8}. What is the molar solubility of lead(II) fluoride?

$PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$

I	–	0	0
C	–	+x	+2x
E	–	x	2x

$K_{sp} = [Pb^{2+}][F^-]^2 = 4.1 \times 10^{-8}$

$(x)(2x)^2 = 4.1 \times 10^{-8}$

$4x^3 = 4.1 \times 10^{-8}$

$x = \left(\frac{4.1 \times 10^{-8}}{4}\right)^{1/3}$

$x = 2.2 \times 10^{-3}$ which is the molar solubility of PbF_2