CHM 1410-002
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 $HF(aq) + OH^-(aq) \leftrightarrows F^-(aq) + H_2O(l)$, the conjugate acid-base pairs are

	pair 1	*pair 2*
A.	HF and OH^-;	F^- and H_2O.
(B.)	HF and F^-;	OH^- and H_2O.
C.	HF and H_2O;	OH^- and F^-.
D.	HF and H_3O^+;	OH^- and F^-.
E.	H_3O^+ and OH^-;	HF and H_2O.

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 basic 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 $BaSO_4$?

A. Lowering the pH of the solution
B. Adding a solution of PbI_2
(C.) Adding a solution of $Ba(NO_3)_2$
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 ($CaF_2(s) \leftrightarrows Ca^{2+}(aq) + 2F^-(aq)$)

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 *least* acidic to *most* 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 *least* basic to *most* 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 6.71×10^{-2} M NaOH solution.

$NaOH \rightarrow Na^+ + {}^-OH$ $\quad [{}^-OH] = 6.71 \times 10^{-2}$

$pOH = -\log(6.71 \times 10^{-2}) = 1.17$

$pH + pOH = 14$

$pH = 14 - pOH = 14 - 1.17$

$pH = 12.83$

2.(10) Calculate the pH of a 0.50 M solution of ascorbic acid (Vitamin C, $K_a = 8.0 \times 10^{-5}$)

	$HA \rightleftharpoons$	H^+	$+ A^-$
I	0.50	0	0
C	−x	+x	+x
E	0.50−x	x	x

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

$8.0 \times 10^{-5} = \frac{(x)(x)}{0.50 - x}$ if $x \ll 0.50$ then

$8.0 \times 10^{-5} = \frac{x^2}{0.50}$

$(8.0 \times 10^{-5})(0.50) = x^2$

$6.32 \times 10^{-3} = x = [H^+]$ $\quad \frac{6.32 \times 10^{-3}}{0.50} \times 100 = 1.38$ ✓

$pH = -\log(6.32 \times 10^{-3}) = 2.20$

3.(10) Calculate the pH of a 0.25 M solution of caffeine ($K_b = 4.1 \times 10^{-4}$)

If B = caffeine. $B + H_2O \rightleftharpoons BH^+ + {}^-OH$

	B	H_2O	BH^+	^-OH
I	0.25	-	0	0
C	-x	-	+x	+x
E	0.25-x		x	x

Kb

$K_b = 4.1 \times 10^{-4} = \frac{(x)(x)}{0.25 - x}$ if $x \ll 0.25$ then

$4.1 \times 10^{-4} = \frac{x^2}{0.25}$; $(4.1 \times 10^{-4})(0.25) = x^2$

$1.01 \times 10^{-2} = x = (^-OH)$

$\frac{1.01 \times 10^{-2}}{0.25} \times 100 = 4\%$ ✓

$pOH = -\log(1.01 \times 10^{-2}) = 2.0$

$pH = 14 - 2.0 = 12.0$

4.(10) In pills, Vitamin C is often administered as sodium ascorbate. Calculate the pH of a 0.25 M solution of sodium ascorbate (refer to question 2 for important information).

$NaA \rightarrow Na^+ + A^-$

$K_a = 8.0 \times 10^{-5}$ (ascorbic acid)

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

$A^- + H_2O \rightleftharpoons HA + {}^-OH$

	A^-	H_2O	HA	^-OH
I	0.25	-	0	0
C	-x		+x	+x
E	0.25-x		x	x

$K_b = 1.25 \times 10^{-10} = \frac{(HA)(^-OH)}{(A^-)} = \frac{(x)(x)}{0.25 - x}$

if $x \ll 0.25$ then

$1.25 \times 10^{-10} = \frac{x^2}{0.25}$

$(1.25 \times 10^{-10})(0.25) = x^2$, $5.59 \times 10^{-6} = x = (^-OH)$

$pOH = -\log(^-OH) = -\log(5.59 \times 10^{-6}) = 5.25$

$pH = 14 - pOH$

$pH = 14 - 5.25 = 8.75$

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

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

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

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

$$pH = 4.10 + \log (0.5)$$

$$pH = 3.80$$

6.(10) The K_{sp} value for lead(II) iodide (PbI_2) is 1.4×10^{-8}. What is the molar solubility of lead(II) iodide?

$$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$$

I	-	0	0
C	-	+x	+2x
E	-	x	2x

$$K_{sp} = 1.4 \times 10^{-8} = [Pb^{2+}][I^-]^2$$

$$1.4 \times 10^{-8} = (x)(2x)^2$$

$$1.4 \times 10^{-8} = 4x^3$$

$$\left(\frac{1.4 \times 10^{-8}}{4}\right)^{1/3} = x$$

$1.5 \times 10^{-3} = x$ which is the molar solubility of PbI_2