Chem 255
Spring 2011
Exam 1 Key

1. A) ibuprofen is an acid $pK_a = 4.420$ $K_a = 3.80x10^{-5}$

$$K_a = \frac{[H^+][A^-]}{[HA]} = 3.80x10^{-5}$$

	HA	H^+	A^-
Initial	F = 7.05 x 10^{-5}	0	0
Final	F-x	x	x

$$K_a = \frac{x^2}{F - x} = \frac{x^2}{7.05x10^{-5} - x}$$

$x^2 + 3.80x10^{-5}(x) - 2.679x10^{-9} = 0$

x = 3.61 x 10^{-5} = $[H^+]$ ⇒ **pH = 4.442**

B) 1.05 x 10^{-19} M solution is so dilute that the major equilibrium is that of water:

$H_20 \leftrightarrow H^+ + OH^-$

Thus, the pH will be that of pure water **pH = 7.00**

2. A) $HOBr \leftrightarrow H^+ + OBr^-$ K = $2.00x10^{-9}$

$HOCl + OBr^- \leftrightarrow HOBr + OCl^-$ $K = \frac{1}{6.67x10^{-2}}$ = 14.99 reaction reversed ∴ K inverted

Add two reactions together and therefore multiply two K values together to get

$HOCl \leftrightarrow H^+ + OCl^-$ **$K = (2.00x10^{-9})(14.99) = 3.00x10^{-8}$**

B) pH = 3.98 $[H^+] = 1.047x10^{-4}$

	$HOCl \Leftrightarrow$	H^+	$+ \quad OCl^-$
Initial	F	0	0
Final	F - x	x	x

$$3.00x10^{-8} = \frac{x^2}{F - x} \qquad x = 1.047x10^{-4}$$

$$3.00x10^{-8} = \frac{\left(1.047x10^{-4}\right)^2}{F - 1.047x10^{-4}}$$

$$3.00x10^{-8}F - 3.14x10^{-12} = 1.096x10^{-8}$$

$$F = \frac{1.096x10^{-8}}{3.00x10^{-8}}$$

F = 0.37 M

3. A) Procaine is a base, and thus K_b must be used

$$K_b = \frac{1.00x10^{-14}}{1.16x10^{-9}} = 8.62x10^{-6}$$

$$B + H_2O \Leftrightarrow BH^+ + OH^-$$

$$K_b = \frac{[BH^+][OH^-]}{[B]} = 8.62\times10^{-6} = \frac{x^2}{F-x} = \frac{x^2}{3.25x10^{-4} - x}$$

$$x^2 + 8.62\times10^{-6}x - 2.80\times10^{-9} = 0$$

$$\text{plug into quadratic formula: } x = \frac{-8.62\times10^{-6} \pm \sqrt{(8.62\times10^{-6})^2 - 4(-2.80\times10^{-9})}}{2} = 4.878\times10^{-5} = [OH^-]$$

$$[OH^-] = 4.88\times10^{-5}\,M$$

$$pOH = 4.312$$

pH = 9.688

B) if pH is controlled at 7.40, $[H^+] = 3.98 \times 10^{-8}$, $[OH^-] = 2.51 \times 10^{-7}$

	B	BH^+	OH^-
Initial	3.25×10^{-4}	0	2.51×10^{-7}
Final	3.25×10^{-4}-x	x	2.51×10^{-7}

$$K_b = \frac{[BH^+][OH^-]}{[B]} = \frac{x(2.51x10^{-7})}{3.25x10^{-4} - x} = 8.62x10^{-6}$$

$(2.51x10^{-7})x = 2.8015x10^{-9}-(8.62x10^{-6})x$

$(8.871x10^{-6})x = 2.8015x10^{-9}$

$x = 3.158 \times 10^{-4} = [BH^+]$

fraction in BH^+ form = $\frac{3.158x10^{-4}}{3.25x10^{-4}} = 0.9717 \Rightarrow 97.17\%$

$\therefore$ **percent that is neutral (B) = 2.83%**

4. $z_{124.8} = \left|\frac{124.8 - 118.2}{6.00}\right| = 1.1$

area for z = 1.1 = 0.3643

thus, the percentage above 124.8 ppm is **0.5000-0.3643 = 0.1357 = 13.57%**

5. A) the larger the K_a, the larger $[H^+]$ and thus the lower the pH

haloperidol $K_b = 2.00x10^{-6}$ $K_a = 5.00x10^{-9}$
HCl is a strong acid and completely dissociated
Water is neutral with pH = 7

a > c > d > e > b

B) The smaller the K_a (or K_b) value, the smaller the fraction of ionization.
The larger the concentration of a given species, the smaller the fraction of ionization

b > c > a

C) The larger the concentration of a given weak acid, the larger the $[H^+]$, thus the lower the pH

b < a

6. use t-test to determine if difference exists

determine s_{pooled} =

$$\sqrt{\frac{(s_1)^2(n_1-1)+(s_2)^2(n_2-1)}{n_1+n_2-2}} = \sqrt{\frac{(0.48)^2(2)+(0.23)^2(6)}{10-2}} = 0.3119$$

$$t = \frac{x_2 - x_1}{s_{pooled}}\sqrt{\frac{(n_1)(n_2)}{n_1+n_2}} = \frac{36.35-35.82}{0.3119}\sqrt{\frac{21}{10}} = 2.4625$$

for 95% level, 7 degrees of freedom, $t_{table} = 2.306$

thus, since $t_{calc} > t_{table}$, there is a statistical difference at the 95% confidence level

7. A) $BaF_{2\,(s)} \leftrightarrow Ba^{+2} + 2F^-$

	$BaF_{2\,(s)} \Leftrightarrow Ba^{+2} + 2F^{-}$		
Initial	solid	0	0
Final	solid	x	2x

$K_{sp} = (x)(2x)^2 = 1.7x10^{-6}$

$1.7x10^{-6} = 4x^3$

$x = 7.5x10^{-3}$

$\mathbf{[Ba^{+2}] = x = 7.5x10^{-3}\ M}$

B) $BaF_{2\,(s)} \leftrightarrow Ba^{+2} + 2F^{-}$ $NaF \rightarrow Na^{+} + F^{-}$

	$BaF_{2\,(s)} \Leftrightarrow Ba^{+2}$	+	$2F^{-}$
Initial	solid	0	X
Final	solid	$2.3x10^{-3}$	$X + 4.6x10^{-3}$

$K_{sp} = (2.3x10^{-3})(X+4.6x10^{-3})^2 = 1.7x10^{-6}$

$1.7x10^{-6} = 2.3x10^{-3}(X^2 + 9.2x10^{-3}X + 2.12x10^{-5})$

$X^2 + 9.2x10^{-3}X - 7.178x10^{-4} = 0$

$x = 2.26x10^{-2} = [F^{-}]$

$\therefore$ **add $\mathbf{2.3x10^{-2}}$ M NaF**

8. A) Concentration of lead will increase. The added NaCl will increase the ionic strength. As the ionic strength of the solution increases, the activity coefficients will decrease, and the concentration of the products will increase.

B) The concentration of lead ion in beaker #3 will be higher than beaker #2. The ionic strength will be larger for 0.05 M $CaCl_2$ than for 0.1 M NaCl because the ionic strength varies with the square of the ion charge (charge on Ca = +2, charge on sodium = +1). Therefore, since the ionic strength in beaker #3 is larger, the concentration of lead ions in solution will be larger in beaker #3.