Acid-Base Equilibria

1. What is the formula for percent ionization?

2. A solution of HCl has a pH of 2.3. Calculate the pOH, $[H^+]$, and $[OH^-]$
   pOH = 11.7
   $[H^+]$ = 5.0×10^{-3}
   $[OH^-]$ =

   $pH = -\log[H^+]$
   $10^{2.3} = 5.0 \times 10^{-3}$

   $14 = pOH + pH$
   $14 = pOH + 2.3$
   $pOH = 11.7$

3. What is the concentration of hydronium ions in a solution that has a volume of 2.50 L and 5.33 g of HCl? What is the pH of this solution?

   $5.33\ g\ HCl \left| \frac{1\ mol\ HCl}{36.46\ g\ HCl} \right| \frac{1\ mol\ H^+}{1\ mol\ HCl} = 0.146\ mol\ H^+$

   $[H^+] = \frac{0.146\ mol}{2.50\ L} = 0.0584\ M\ H^+$

   $pH = -\log[0.0584]$
   $pH = 1.234$

4. Calculate the pH of a solution prepared by mixing 0.15M HF with 0.18M NaF.
   (K_a of HF is 6.8×10^{-4}, $pK_a = 3.17$)

   ① $[HA] = 0.15M$
   $[A^-] = 0.18M$

   ② $pH = 3.17 + \log\frac{[0.18]}{[0.15]}$

   $pH = 3.25$

5. Calculate the pH of a solution that is 0.20M in $HCHO_2$ and 0.15M in $NaCHO_2$

	$HCHO_2$	$\rightleftharpoons$ H^+	+ CHO_2^-
I	0.20	0	0.15 M
C	$-x$	$+x$	$+x$
E	$0.20 - x$	x	$0.15 + x$
	≈ 0.20		≈ 0.15

$K_a = 1.8 \times 10^{-4}$

$1.8 \times 10^{-4} = \frac{[H^+][CHO_2^-]}{[CCHO_2]}$

$1.8 \times 10^{-4} = \frac{0.15x}{0.20}$
$x = 2.4 \times 10^{-4}$

$pH = 3.62$

6. Vinegar is a dilute solution of acetic acid ($HC_2H_3O_2$). If the concentration of $HC_2H_3O_2$ in a vinegar solution is 0.210M, calculate the percent ionization of acetic acid. ($K_a = 1.75 \times 10^{-5}$)

$HA + H_2O \rightleftharpoons H^+ + A^-$

	HA		H^+	A^-
I	0.210		0	0
C	-x		+x	+x
E	0.21 -x		x	x

$1.75 \times 10^{-5} = \frac{x^2}{0.210}$

$x = \sqrt{(1.75 \times 10^{-5})(0.210M)}$

$= 0.001917M$

$\%I = \frac{[H^+]}{[HA]} \times 100 \quad \%I = \frac{0.001917}{0.210} \times 100$

$\%I = 0.913\%$

7. Calculate the percent ionization in a 1.0M solution of nitrous acid. ($K_a = 4.5 \times 10^{-4}$)

$HNO_2 \rightleftharpoons H^+ + NO_2^-$

	HNO_2		H^+	NO_2^-
I	1.0M		0	0
C	-x		+x	+x
E	1.0-x		x	x

$4.5 \times 10^{-4} = \frac{x^2}{1.0}$

$x = \sqrt{(4.5 \times 10^{-4})(1)}$

$= 2.1 \times 10^{-2} M$

$\%I = \frac{[H^+]}{[1.0]} = 2.1\%$

8. If the hydrogen ion concentration of a solution is 2.5×10^{-5}M, what is the pH of the solution?

$pH = -\log(2.5 \times 10^{-5})$

$pH = 4.60$

9. What is the pOH of a solution with a pH of 8.72?

$14 - 8.72 =$

$pOH = 5.28$

10. What is the pH of a 0.50M ammonia, NH_3 solution? The K_b of ammonia is 1.8×10^{-5}.

	NH_3	+ H_2O ⇌	OH^-	+ NH_4^+
I	0.50	—	0	0
C	−x	—	+x	+x
E	0.50−x	—	x	x

$$K_b = \frac{[OH^-][NH_4^+]}{[NH_3]}$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.50}$$

$$x^2 = 9 \times 10^{-6}$$

$$x = 3.0 \times 10^{-3}\ M = [OH^-]$$

$$pOH = -\log(3.0 \times 10^{-3})$$

$$pOH = 2.5$$