Name _____ Date _____

In this section, you are only going to start the problem by identifying the type of problem and writing the chemical equation for the following substances dissolved in water:

1. Acetic acid $HC_2H_3O_2 \rightleftharpoons H^+ + C_2H_3O_2^-$

2. Perchloric acid
$HClO_4 \longrightarrow H^+ + ClO_4^-$

3. Ammonia
$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

4. Sodium hydroxide
$NaOH \longrightarrow Na^+ + OH^-$

5. N_2H_4
$N_2H_4 + H_2O \rightleftharpoons N_2H_5^+ + OH^-$

6. Ammonium chloride $NH_4Cl \longrightarrow NH_4^+ + Cl^-$
$NH_4^+ \rightleftharpoons NH_3 + H^+$

7. Lithium fluoride $LiF \longrightarrow Li^+ + F^-$
$F^- + H_2O \rightleftharpoons HF + OH^-$

8. Potassium nitrite $KNO_2 \longrightarrow K^+ + NO_2^-$
$NO_2^- + H_2O \rightleftharpoons HNO_2 + OH^-$

9. Sodium acetate $NaC_2H_3O_2 \longrightarrow Na^+ + C_2H_3O_2^-$
$C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^-$

10. Phosphoric acid
$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$
$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{-2}$
$HPO_4^{-2} \rightleftharpoons H^+ + PO_4^{-3}$

Calculate the pH of the following 0.50 M solutions:

1. Hydrochloric acid
2. Chlorous acid
3. Ammonia
4. Sodium hydroxide
5. Sodium fluoride
6. Ammonium nitrate
7. Formic acid (HCOOH) and Hypobromous acid (HOBr)
8. Phosphoric acid

$HCl \rightarrow H^+ + Cl^-$

$[HCl] = [H^+] = 0.50$

$pH = -\log(0.50) = 0.30$

$HClO_2 \rightleftharpoons H^+ + ClO_2^-$

	$HClO_2$	H^+	ClO_2^-
I	0.50	0	0
C	$-x$	$+x$	$+x$
E	$0.50-x$	x	x

$K_a = \frac{[H^+][ClO_2^-]}{[HClO_2]}$

$1.2 \times 10^{-2} = \frac{x^2}{0.50-x}$

$x = 0.077\ M = [H^+]$

$5\% \quad \frac{0.077}{0.50} \times 100 = 15\%$!! quadratic

3) $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

	NH_3		NH_4^+	OH^-
I	0.50		0	0
C	$-x$		$+x$	$+x$
E	$0.50 - x$		x	x

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

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

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

$$\text{So, } \frac{3.0 \times 10^{-3}}{0.50} \times 100 = 0.6\% \checkmark$$

$$pOH = -\log(3.0 \times 10^{-3}) = 2.52$$

$$pH = 14 - 2.52 = 11.48$$

4) $NaOH \rightarrow Na^+ + OH^-$

$$[NaOH] = [OH^-] = 0.50\ M$$

$$pOH = -\log(0.50) = 0.30$$

$$pH = 14 - 0.30 = 13.70$$

5) $NaF \longrightarrow Na^+ + F^-$

$F^- + H_2O \rightleftharpoons HF + OH^-$

	F^-	H_2O	HF	OH^-
I	0.50		0	0
C	$-x$		$+x$	$+x$
E	$0.50-x$		x	x

$$K_b = \frac{[HF][OH^-]}{[F^-]}$$

$$1.38 \times 10^{-11} = \frac{x^2}{0.50-x}$$

$$x = 2.64 \times 10^{-6}\ M = [OH^-]$$

So $\frac{2.64 \times 10^{-6}}{0.50} \times 100 = 5.27 \times 10^{-4}\%$

$$pOH = -\log(2.64 \times 10^{-6}) = 5.58$$

$$pH = 8.42$$

b) $NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$

$NH_4^+ \rightleftharpoons NH_3 + H^+$

	NH_4^+	NH_3	H^+
I	0.50	0	0
C	$-x$	$+x$	$+x$
E	$0.50-x$	x	x

$$K_a = \frac{[NH_3][H^+]}{[NH_4^+]}$$

$$K_a = \frac{K_w}{K_b} = \frac{1.0\times10^{-14}}{1.8\times10^{-5}} = 5.56\times10^{-10}$$

$$5.56\times10^{-10} = \frac{x^2}{0.50-x}$$

$$x = 1.7\times10^{-5}\,M = [H^+]$$

$$\text{Soln. } \frac{1.7\times10^{-5}}{0.50}\times100 = 1.7\times10^{-2}\%$$

$$pH = -\log(1.7\times10^{-5}) = 4.77$$

7. $HCOOH \rightleftharpoons H^+ + COOH^-$

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

$HOBr \rightleftharpoons H^+ + OBr^-$

$K_a = 2 \times 10^{-9}$

	$HCOOH$	$\rightleftharpoons$	H^+	$+$	$COOH^-$
I	0.50		0		0
C	$-x$		$+x$		$+x$
E	$0.50 - x$		x		x

$$K_a = \frac{[H^+][COOH^-]}{[HCOOH]}$$

$$1.8 \times 10^{-4} = \frac{x^2}{0.50 - x}$$

$x = 9.5 \times 10^{-3} M = [H^+] = [COOH^-]$

$pH = -\log(9.5 \times 10^{-3})$

$= 2.02$

	$HOBr$	$\rightleftharpoons$	H^+	$+$	OBr^-
I	0.50		9.5×10^{-3}		0
C	$-x$		$+x$		$+x$
E	$0.50 - x$		$9.5 \times 10^{-3} + x$		x

$$K_a = \frac{[H^+][OBr^-]}{[HOBr]}$$

$$2 \times 10^{-9} = \frac{(9.5 \times 10^{-3} + x)(x)}{0.50 - x}$$

$x = 1.05 \times 10^{-7} M$

$[OBr^-]$

$\%\text{ ion} = \frac{1.05 \times 10^{-7}}{9.5 \times 10^{-3}} =$

0.11% ✓

	H_2CO_3	H^+	HCO_3^-
I	0.50	0	0
C	$-x$	$+x$	$+x$
E	$0.50-x$	x	x

$$K_a = \frac{[H^+][H_2PO_4^-]}{[H_3PO_4]}$$

$$4.3\times10^{-7} = \frac{x^2}{0.50-x}$$

$$x = 4.6\times10^{-4}\ M = [H^+]$$

$$\%\ \text{ion} = \frac{4.6\times10^{-4}}{0.50}\times 100 = 0.09\%$$ ✓