Ex A.
What is the pH of 0.50M HCl?

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$
0.50 0.50

$pH = -\log[0.50] = \mathbf{0.30}$

Name: Key
Blk:___Date:___________

CHEMISTRY 12
ACID BASES UNIT
Lesson #12

Calculations Involving K_a and pH

IMPT: The pH scale is NOT LINEAR!!! When the pH is increased by 1, the [H3O+] is DECREASED by 10!!!

Recall that Strong Acids IONIZE 100 %, therefore the concentration of the strong acid will eqaul the concentration of H3O+ in solution!!

HOWEVER, Weak acids DO NOT IONIZE 100% in water, thereforewe must use an ICE TABLE to determine the [H3O+] that is actually present in solution!

Generic Equation for a WEAK ACID in water:

$$HA + H_2O \leftrightarrow A^- + H_3O^+$$

There are THREE types of problems that you can solve associated with a weak acid:

Type 1. Given the K_a and the concentration of the weak acid, solve for the pH
Example 1. What is the pH for a 0.500 M solution of CH_3COOH?
Step 1 . Write out the ionization equation with water

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

Step 2. Write out the K_a expression, identify the Ka value

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = 1.8 \times 10^{-5}$$

Step 3. Set up an ICE TABLE for acetice acid

	$CH_3COOH_{(aq)}$ +	$H_2O_{(l)}$ $\rightleftharpoons$	$CH_3COO^-_{(aq)}$ +	$H_3O^+_{(aq)}$
I	0.500		$\cancel{0}$	$\cancel{0}$
C	$-x$		$+x$	$+x$
E	$0.500 - x \approx 0.500$		x	x

Step 4. Plug values into K_a and solve for x

$$1.8 \times 10^{-5} = \frac{[x][x]}{0.500} = \frac{x^2}{0.500} \rightarrow \sqrt{1.8 \times 10^{-5} \times 0.500} = \sqrt{x^2}$$

$$\underline{3.0} \times 10^{-3} = x$$

Step 5. Use x to solve for pH

$$\therefore [H_3O^+] = 3.0 \times 10^{-3} \quad pH = -\log[H_3O^+] = \boxed{2.52}$$

Type 2. Given the pH and the initial concentration of the weak acid, solve for the K_a value.

Example 2. If the pH of a 0.100 M solution of an unknown weak acid is 1.70, determine the K_a and identify the weak acid.

Step 1 . Write out the generic ionization with water

$$HA\,(aq) + H_2O\,(l) \rightleftharpoons A^-\,(aq) + H_3O^+\,(aq)$$

Step 2. Set up an ICE TABLE for the weak acid

	HA	$+\ H_2O$	$\rightleftharpoons A^-$	$+\ H_3O^+$
I	0.100		$\emptyset$	$\emptyset$
C	-1.99×10^{-2}		$+1.99\times10^{-2}$	$+1.99\times10^{-2}$
E	8.0×10^{-2}		1.99×10^{-2}	1.99×10^{-2}

Step 3. Use the pH to fill in the values of the ICE TABLE

$$pH = 1.\underline{70} \quad \therefore [H_3O^+]_E = \text{antilog}(-1.70) \Rightarrow 1.99\times10^{-2}$$

Step4. Use the equilibrium values to calculate the K_a

$$Ka = \frac{[1.99\times10^{-2}][1.99\times10^{-2}]}{8.0\times10^{-2}} \rightarrow 5.0\times10^{-3}$$

$\therefore$ either Citric or Iron III

Type 3. Given pH and K_a, determine the initial concentration of the weak acid.

Example 3. What concentration of H_2CO_3 is required to produce a pH of 4.18?

Step 1 . Write out the ionization with water

$$H_2CO_3\,(aq) + H_2O\,(l) \rightleftharpoons HCO_3^-\,(aq) + H_3O^+$$

Step 2. Write out the K_a expression, look up K_a value

$$Ka = \frac{[HCO_3^-][H_3O^+]}{[H_2CO_3]} = 4.3\times10^{-7}$$

Step 3. Set up an ICE TABLE for H_2CO_3

	$H_2CO_3\,(aq)$	$+\ H_2O\,(l)$	$\rightleftharpoons HCO_3^-\,(aq)$	$+\ H_3O^+\,(aq)$
I	X		$\emptyset$	$\emptyset$
C	-6.6×10^{-5}		$+$	$+6.6\times10^{-5}$
E	$X-6.6\times10^{-5} \triangleq X$		$+6.6\times10^{-5}$	6.6×10^{-5}

Step 4. Use pH to fill in the table

$$pH = 4.18 \quad \therefore [H_3O^+]_E = \text{antilog}(-4.18) = 6.6\times10^{-5}$$

Step 5. Use K_a to solve for initial concentration $\rightarrow$

$$4.3\times10^{-7} = \frac{[6.6\times10^{-5}]^2}{X}$$

$$X = \frac{[6.6\times10^{-5}]^2}{4.3\times10^{-7}}$$

$$X = 1.0\times10^{-2}\ M$$

Seatwork/Homework: Exercises 74-78, 80, 82-83

PLO's: Part of M3 and M5 for K_a

$$\boxed{[H_2CO_3]_I = 1.0\times10^{-2}\ M}$$