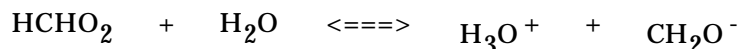


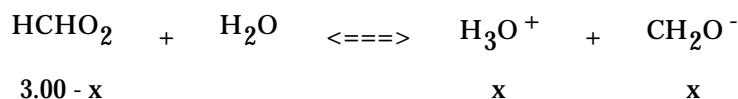
## Equilibrium Calculations with a Graphing Calculator

Equations using the equilibrium constant can be analyzed using a quadratic equation and a graphing calculator. The amount of product formed can be predicted from the beginning amount of reactant.

**For example:** Predict how many  $\text{H}_3\text{O}^+$  and  $\text{CH}_2\text{O}^-$  ions will be formed when 3.00 mol of formic acid,  $\text{HCHO}_2$ , is added to 1.00 L of water;  $K_{\text{eq}} = 1.8 \times 10^{-4}$



First, write out the equilibrium equation:



Solve the equation for zero.

$$K_{\text{eq}} = \frac{[\text{H}_3\text{O}^+] \cdot [\text{CH}_2\text{O}^-]}{[\text{HCHO}_2]}$$

$$1.8e-4 = \frac{x^2}{3.00 - x}$$

$$0 = x^2 + 1.8e-4x - 5.4e-4$$

Graph the quadratic equation and find the value of the x-intercept. This value represents the x-term which is the concentrations of  $\text{H}_3\text{O}^+$  and  $\text{CH}_2\text{O}^-$ .  $[\text{HCHO}_2]$  will be 3.00 minus the x-intercept. ( $0.023 \text{ M} = \text{H}_3\text{O}^+$ ,  $\text{CH}_2\text{O}^-$ ;  $2.977 \text{ M} = \text{HCHO}_2$ )

- What concentrations of  $\text{H}_3\text{O}^+$  and  $\text{CH}_2\text{O}^-$  will result from 3.50 M  $\text{HCHO}_2$ ?
- What concentrations of  $\text{H}_3\text{O}^+$  and  $\text{CH}_2\text{O}^-$  will result from 5.00 M  $\text{HCHO}_2$ ?
- What concentrations of  $\text{H}_3\text{O}^+$  and  $\text{ClO}_2^-$  will result from the dissociation of 3.00 M  $\text{HClO}_2$ ? ( $K_{\text{eq}} = 1.2 \times 10^{-2}$ )

### Data Analysis

Data analysis equipment can measure the concentration of specific ions in solution. The  $\text{H}_3\text{O}^+$  concentration of solution can be analyzed using a pH meter. First, calculate the theoretical  $[\text{H}_3\text{O}^+]$  for the reaction of each of the following acids in water using the  $K_{\text{eq}}$ . Analyze your data by organizing a table ranking the acids from highest  $[\text{H}_3\text{O}^+]$  to the lowest  $[\text{H}_3\text{O}^+]$ .

Acid	$K_{\text{eq}}$
3.00 M HCN	$4.0 \times 10^{-10}$
3.00 M HF	$6.7 \times 10^{-4}$
3.00 M HOCl	$2.95 \times 10^{-8}$
3.00 M $\text{HC}_2\text{H}_2\text{ClO}_2$	$1.35 \times 10^{-3}$
3.00 M $\text{HNO}_2$	$5.13 \times 10^{-4}$