During Class Invention
Neutralization Reactions

Name___________________________

1. Write the ionic and net ionic equations for the following reactions, the equilibrium expression for the net ionic equation, and determine the magnitude of the equilibrium constant.
   a) $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

ion reaction $H^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow H_2O(l) + Na^+(aq) + Cl^-(aq)$

net ion reaction $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

$$K = \frac{1}{[H^+][OH^-]} = \frac{1}{K_w} = \frac{1}{1 \times 10^{-14}} = 1.0 \times 10^{14}$$

   b) $HC_2H_3O_2(aq) + KOH(aq) \rightarrow H_2O(l) + KC_2H_3O_2(aq)$

First we need to write the net ionic equation:

$$HC_2H_3O_2(aq) + OH^-(aq) \rightarrow H_2O(l) + C_2H_3O_2^-(aq)$$

We need to break this equation into two equations whose K values we know. So looking at the net ionic equation I see $HC_2H_3O_2(aq)$ which is a weak acid, and I know how it dissociates;

$$HC_2H_3O_2(aq) \rightarrow H^+(aq) + C_2H_3O_2^-(aq)$$

The equilibrium constant for this reaction is $K_a(HC_2H_3O_2)$. The other equation has $H_2O(l)$ in it;

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

The equilibrium constant for this reaction is $\frac{1}{K_w}$. So if I add these two equations (I must multiply the equilibrium constants) I get the equation that we started with;

$$HC_2H_3O_2(aq) + OH^-(aq) \rightarrow H_2O(l) + C_2H_3O_2^-(aq)$$

And the equilibrium constant for this reaction is;

$$K_a \cdot \frac{1}{K_w} = \frac{K_a}{K_w}$$

$$K_{rxn} = \frac{1.8 \times 10^{-5}}{1 \times 10^{-14}} = 1.8 \times 10^{9}$$

Another approach to solve this same problem is;

ion reaction $HC_2H_3O_2(aq) + K^+(aq) + OH^-(aq) \rightarrow H_2O(l) + K^+(aq) + C_2H_3O_2^-(aq)$

net ion reaction $HC_2H_3O_2(aq) + OH^-(aq) \rightarrow H_2O(l) + C_2H_3O_2^-(aq)$

$$K_{rxn} = \frac{[C_2H_3O_2^-]}{[OH^-][HC_2H_3O_2]}$$

multiply the expression by $\frac{[H^+]}{[H^+]}$

$$K_{rxn} = \frac{[C_2H_3O_2^-]}{[OH^-][HC_2H_3O_2]} \cdot \frac{[H^+]}{[H^+]}$$

$$K_{rxn} = \frac{[C_2H_3O_2^-][H^+]}{[HC_2H_3O_2]} \cdot \frac{1}{[H^+][OH^-]}$$

$$K_{rxn} = K_a \cdot \frac{1}{K_w} = \frac{K_a}{K_w}$$

$$K_{rxn} = \frac{1.8 \times 10^{-5}}{1 \times 10^{-14}} = 1.8 \times 10^9$$

c) $HNO_3(aq) + NH_3(aq) \rightarrow NH_4NO_3(aq)$

ion reaction $H^+(aq) + NO_3^-(aq) + NH_3(aq) \rightarrow NH_4^+(aq) + NO_3^-(aq)$

net ion reaction $H^+(aq) + NH_3(aq) \rightarrow NH_4^+(aq)$

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

multiply the expression by $\frac{[OH^-]}{[OH^-]}$

$$K = \frac{[NH_4^+]}{[H^+][NH_3]} \cdot \frac{[OH^-]}{[OH^-]}$$

$$K = \frac{[NH_4^+][OH^-]}{[NH_3]} \cdot \frac{1}{[H^+][OH^-]}$$

$$K = K_b \cdot \frac{1}{K_w} = \frac{K_b}{K_w}$$

$$K = \frac{1.8 \times 10^{-5}}{1 \times 10^{-14}} = 1.8 \times 10^9$$

What is the general conclusion which can be made from the magnitude of the equilibrium constant in all three examples above?

All three reaction have very large equilibrium constants, indicating that all three reactions proceed completely to products.