During Class Invention
Salts I

Name_____

1. Define the term *salt*.

   Salts are ionic compounds which are formed in a neutralization reaction between an acid and a base. Salts can be characterized from the type of acid and base which combine in the neutralization reaction. Salts can be formed from the reaction of a strong acid and a strong base, a strong acid and a weak base, a weak acid and a strong base or a weak acid and a weak base.

2. Complete the following table.

Solution	pH	Equilibrium $[H^+]$ or $[OH^-]$	Acidic, basic or neutral
0.100 M NaCl	**7**	**$[H^+] = [OH^-] = 1 \times 10^{-7}$ M**	**neutral**
0.100 M $NaC_2H_3O_2$	**8.9**	**$[H^+] = 1.34 \times 10^{-9}$ M**	**basic**
		$[OH^-] = 7.45 \times 10^{-6}$ M	
0.100 M NH_4Cl	**5.1**	**$[H^+] = 7.45 \times 10^{-6}$ M**	**acidic**
		$[OH^-] = 1.34 \times 10^{-9}$ M	

3. Predict the product of the neutralization reactions,

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow \mathbf{NaCl_{(aq)} + H_2O_{(l)}}$$

$$HC_2H_3O_{2(aq)} + NaOH_{(aq)} \rightarrow \mathbf{NaC_2H_3O_{2(aq)} + H_2O_{(l)}}$$

$$HCl_{(aq)} + NH_{3(aq)} \rightarrow \mathbf{NH_4Cl_{(aq)}}$$

4. In general, what is the acid-base property of any salt formed in the reaction between a strong acid and a strong base?

   NaCl is a neutral salt. In general, salts formed from the reaction between a strong acid and a strong base are neutral.

5. In general, what is the acid-base property of any salt formed in the reaction between a strong acid and a weak base?

   NH_4Cl is an acidic salt. In general, salts formed from the reaction between a strong acid and a weak base are acidic.

6. In general, what is the acid-base property of any salt formed in the reaction between a weak acid and a strong base?

   $NaC_2H_3O_2$ is an basic salt. In general, salts formed from the reaction between a weak acid and a strong base are basic.

7a. Write the dissociation equation which describes what happens when $NaC_2H_3O_2(s)$ is added to water.

$NaC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons HC_2H_3O_2(aq) + NaOH(aq)$

$C_2H_3O_2^-(aq) + H_2O(l) \rightleftharpoons HC_2H_3O_2(aq) + OH^-(aq)$ net ionic equation

b. Write the equation which describes the acidic character of $Na^+(aq)$. Write the equilibrium expression and estimate K_a for $Na^+(aq)$.

$Na^+(aq) + H_2O(l) \rightleftharpoons NaOH(aq) + H^+(aq)$

$$\mathbf{K_a = \frac{[NaOH][H^+]}{[Na^+]} = \frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{\text{very large}} = \text{very small}}$$

c. Write the equation which describes the basic character of $C_2H_3O_2^-(aq)$. Write the equilibrium expression and calculate the K_b for $C_2H_3O_2^-(aq)$.

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

$$\mathbf{K_b = \frac{[HC_2H_3O_2][OH^-]}{[C_2H_3O_2^-]} = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}}$$

d. Which of the two ions, $Na^+(aq)$ or $C_2H_3O_2^-(aq)$, affects the pH of the solution? Explain why.

$C_2H_3O_2^-(aq)$ will affect the pH of the solution. Of the two ions formed when $NaC_2H_3O_2$ is added to water, only the $C_2H_3O_2^-(aq)$ has an equilibrium constant which will change the pH of water. The equilibrium constant for Na^+ is so small that it does not change the pH of water.

e. Predict the products when $KCN(s)$ is added to water. Will the pH of the solution formed when the salt is added to water be greater or less than 7?

$KCN(s) \xrightarrow{H_2O} K^+(aq) + CN^-(aq)$

$CN^-(aq) + H_2O(l) \rightleftharpoons HCN(aq) + OH^-(aq)$

KCN is the salt of a strong base and a weak acid. The pH of the solution will be greater than 7.

15a. Write the dissociation equation which describes what happens when $NH_4Cl(s)$ is added to water.

$$NH_4Cl(s) \xrightarrow{H_2O} Cl^-(aq) + NH_4^+(aq)$$

$$NH_4^+(aq) \rightleftharpoons H^+(aq) + NH_3(aq) \quad \textbf{net ionic equation}$$

b. Write the equation which describes the acidic character of $NH_4^+(aq)$. Write the equilibrium expression and calculate K_a for $NH_4^+(aq)$.

$$NH_4^+(aq) \rightleftharpoons H^+(aq) + NH_3(aq)$$

$$K_a = \frac{[NH_3][H^+]}{[NH_4^+]} = \frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$$

c. Write the equation which describes the basic character of $Cl^-(aq)$. Write the equilibrium expression and estimate K_b for $Cl^-(aq)$.

$$Cl^-(aq) + H_2O(l) \rightleftharpoons HCl(aq) + OH^-(aq)$$

$$K_b = \frac{[HCl][OH^-]}{[Cl^-]} = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{\text{very large}} = \text{very small}$$

d. Which of the two ions, $NH_4^+(aq)$ or $Cl^-(aq)$, affects the pH of the solution? Explain why.

Only $NH_4^+(aq)$ will affect the pH of the solution. Of the two ions formed when NH_4Cl is added to water, only the $NH_4^+(aq)$ has an equilibrium constant which will change the pH of water. The equilibrium constant for Cl^- is so small it does not change the pH of water.

e. Predict the products when $CH_3NH_3NO_3(s)$ is added to water. Will the pH of the solution formed when the salt is added to water be greater or less than 7?

$$CH_3NH_3NO_3(s) \xrightarrow{H_2O} CH_3NH_3^+(aq) + NO_3^-(aq)$$

$$CH_3NH_3^+(aq) \rightleftharpoons H^+(aq) + CH_3NH_2(aq)$$

$CH_3NH_3NO_3$ is a salt formed from a weak base (CH_3NH_2) and a strong acid (HNO_3). The resulting solution is acidic, pH less than 7.