**AP Chemistry Problem Set Chapter 14** **Name___________________**

**Multiple Choice.** Please indicate your multiple choice answers below.

1. ___E_____ 2. _____A____ 3. ____B____ 4. ____D___ 5. ____D___

1. $HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$

In the equilibrium represented above, the species that act as bases include which of the following?

I. $HSO_4^-$
II. $H_2O$
III. $SO_4^{2-}$

a. II only b. III only c. I and II d. I and III **e. II and III**

2. $HC_2H_3O_2(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + C_2H_3O_2^-(aq)$

The reaction represented above has an equilibrium constant equal to $3.7 \times 10^4$. Which of the following can be concluded from this information?

**a. $CN^-(aq)$ is a stronger base than $C_2H_3O_2^-(aq)$**
b. $HCN(aq)$ is a stronger acid than $HC_2H_3O_2(aq)$
c. The conjugate base of $CN^-(aq)$ is $C_2H_3O_2^-(aq)$
d. The equilibrium constant will increase with an increase in temperature.
e. The pH of a solution containing equimolar amounts of $CN^-(aq)$ and $HC_2H_3O_2(aq)$ is 7.0.

3. Which of the following will occur when a solution of a weak acid is diluted?

I. The pH of the solution will decrease.
II. The equilibrium constant for the acid will increase.
III. The dissociation of the acid will increase.

a. I only **b. III only** c. I and II only d. II and III only e. I, II, and III

4. The strengths of five acids are listed below in decreasing order:

$HBr > HF > HCN > H_2O > NH_3$

Which one of the following reactions will have an equilibrium constant less than one?

a. $HBr + H_2O \rightleftharpoons H_3O^+ + Br^-$
b. $HF + OH^- \rightleftharpoons H_2O + F^-$
c. $H_2O + NH_2^- \rightleftharpoons NH_3 + OH^-$
**d. $HCN + F^- \rightleftharpoons HF + CN^-$**
e. $HBr + NH_3 \rightleftharpoons NH_4^+ + Br^-$

5. Which salt produces the most alkaline solution at a concentration of 0.1 M?

a. $KNO_3$ b. $MgCl_2$ c. $NH_4Cl$ **d. $NaNO_2$** e. $Na_2SO_4$

**2005 - #1– Average Score: 5.58 out of 10**

$HC_3H_5O_2(aq) \rightleftharpoons C_3H_5O_2^-\,(aq) + H^+(aq)$ $K_a = 1.34 \times 10^{-5}$

Propanoic acid, $HC_3H_5O_2$, ionizes in water according to the equation above.

(a) Write the equilibrium-constant expression for the reaction.

$$K_a = \frac{[H^+][C_3H_5O_2^-]}{[HC_3H_5O_2]}$$

(b) Calculate the pH of a 0.265 *M* solution of propanoic acid. **pH = 2.725**

(c) A 0.496 g sample of sodium propanoate, $NaC_3H_5O_2$, is added to a 50.0 mL sample of a 0.265 *M* solution of propanoic acid. Assuming that no change in the volume of the solution occurs, calculate each of the following.

(i) The concentration of the propanoate ion, $C_3H_5O_2^-$ (*aq*), in the solution **0.103**

(ii) The concentration of the $H^+(aq)$ ion in the solution **$3.45 \times 10^{-5}$ *M***

The methanoate ion, $HCO_2^-(aq)$, reacts with water to form methanoic acid and hydroxide ion, as shown in the following equation.

$HCO_2^-(aq) + H_2O(l) \rightleftharpoons HCO_2H(aq) + OH^-(aq)$

(d) Given that $[OH^-]$ is $4.18 \times 10^{-6}$ *M* in a 0.309 *M* solution of sodium methanoate, calculate each of the following.

(i) The value of $K_b$ for the methanoate ion, $HCO_2^-(aq)$ **$K_b = 5.65 \times 10^{-11}$**

(ii) The value of $K_a$ for methanoic acid, $HCO_2H$ **$K_a = 1.77 \times 10^{-4}$**

(e) Which acid is stronger, propanoic acid or methanoic acid? Justify your answer.

**$K_a$ for propanoic acid is $1.34 \times 10^{-5}$, and $K_a$ for methanoic acid is $1.77 \times 10^{-4}$. For acids, the larger the value of $K_a$, the greater the strength; therefore methanoic acid is the stronger acid because $1.77 \times 10^{-4} > 1.34 \times 10^{-5}$.**

2. Solve each of the following.

a. The pH of blood is 7.4. Calculate the pOH, $[H^+]$, $[OH^-]$ and identify if it is acidic, basic or neutral.

**pOH = 6.6    $[H^+] = 3.98 \times 10^{-8}$    $[OH^-] = 2.51 \times 10^{-7}$    basic**

b. The pOH of a sample of baking soda is 5.74. Calculate the pH, $[H^+]$, $[OH^-]$ and identify if it is acidic, basic or neutral.

**pH = 8.26    $[H^+] = 5.50 \times 10^{-9}$    $[OH^-] = 1.82 \times 10^{-6}$    basic**

c. The pH of a sample of milk is 6.77 at 25°C. Calculate the pOH, $[H^+]$, $[OH^-]$ and identify if it is acidic, basic or neutral.

**pOH = 7.23    $[H^+] = 1.70 \times 10^{-7}$    $[OH^-] = 5.89 \times 10^{-8}$    acidic**

d. The pOH of a sample of ammonia is 2.01. Calculate the pH, $[H^+]$, $[OH^-]$ and identify if it is acidic, basic or neutral.

**pH = 11.99    $[H^+] = 1.02 \times 10^{-12}$    $[OH^-] = 9.77 \times 10^{-3}$    basic**

e. The $[H^+]$ of a sample of lemon juice is $1.4 \times 10^{-3}$. Calculate the pH, pOH, $[OH^-]$ and identify if it is acidic, basic or neutral.

**pH = 2.85    pOH = 11.15    $[OH^-] = 7.08 \times 10^{-12}$    acidic**

3. Monochloroacetic acid, $HC_2H_2ClO_2$, is a skin irritant that is used in “chemical peels” intended to remove the top layer of dead skin from the face and improve complexion. The value of $K_a$ for monochloroacetic acid is $1.35 \times 10^{-3}$.

a. Calculate the pH for a 0.10 M solution of monochloroacetic acid. **pH = 1.94**

b. Calculate the percent dissociation 0.10 M solution of monochloroacetic acid.

**% dissociation = 11.6%**

c. Calculate the pH for a 0.010 M solution of monochloroacetic acid. **pH = 2.44**

d. Calculate the percent dissociation 0.010 M solution of monochloroacetic acid.

**% dissociation = 36.7%**

e. Use Le Chatelier’s principle to explain why percent dissociation increases as the concentration of a weak acid decreases.

**$HA + H_2O \rightleftharpoons H_3O^+ + A^-$**

**The addition of water causes the reaction to shift right, producing more $H^+$ ions.**

f. Even though percent dissociation increases as the concentration of a weak acid decreases, the $[H^+]$ decreases. Explain.

**As more water is added dissociation increases, but not in proportion to the amount of water added. Thus, the solution becomes diluted and has a higher pH.**

4. Are solutions for the following salts acidic, basic or neutral? For those that are not neutral, write balanced equations for the reactions causing the solution to be acidic or basic. The relevant Ka & Kb values are found in tables 14.2 & 14.3 of your text book.

a. KCl - **neutral**
b. $NH_4C_2H_3O_2$ - **neutral**
c. $CH_3NH_3Cl$ - **acidic**
d. KF - **basic**
e. $NH_4F$- **acidic**
f. $CH_3NH_3CN$ - **basic**
g. $NaNO_2$ – **basic**
h. KOCl - **basic**

5. Solve each of the following.

a. Calculate the $[OH^-]$, [H+] and pH of a 0.20 M solution of triethylamine $(C_2H_5)_3N$, $K_b = 4.0 \times 10^{-4}$.

**pH = 11.96** **$[H^+] = 1.10 \times 10^{-12}$** **$[OH^-] = 0.00894$**

b. Calculate the $[OH^-]$, [H+] and pH of a 0.20 M solution of hydroxylamine ($HONH_2$, $K_b = 1.1 \times 10^{-8}$.

**pH = 9.67** **$[H^+] = 2.13 \times 10^{-10}$** **$[OH^-] = 4.69 \times 10^{-5}$**

c. The pH of a $1.7 \times 10^{-3}$ M solution of codeine, $C_{18}H_{21}NO_3$, is 9.59, calculate $[H^+]$, $[OH^-]$ & $K_b$.

**$K_b = 8.90 \times 10^{-7}$** **$[H^+] = 2.57 \times 10^{-10}$** **$[OH^-] = 3.89 \times 10^{-5}$**

d. The pH of a $1.00 \times 10^{-3}$ M solution of pyrrolidine is 10.82, calculate $[H^+]$, $[OH^-]$ & $K_b$.

**$K_b = 4.38 \times 10^{-4}$** **$[H^+] = 1.51 \times 10^{-11}$** **$[OH^-] = 6.61 \times 10^{-4}$**

e. Calculate the percent ionization of each of the bases listed above.

**a. 4.47%** **b. 0.023%** **c. 2.29%** **d. 66.1%**