ACTIVITY/WORKSHOP on IONIC EQUILIBRIUM Name: _____

1. Predict the product(s) for the following reaction, and designate the conjugate acid and conjugate base.

$HCHO_2(aq) + PO_4^{-3}(aq) \leftrightarrow ?$

2. If pH = 6.6, what are the molar concentrations of $H_3O^+(aq)$ and $OH^-(aq)$ in the solution?

3. Lactic acid, $HC_3H_5O_3$, has one acidic hydrogen. A 0.10 M solution of lactic acid has a pH of 2.44. Calculate its K_a.

4. A 0.200 M solution of bromoacetic acid, $BrCH_2COOH$, is 13.2 percent ionized. Using this information, calculate $[BrCH_2COO^-]$, $[H^+]$, $[BrCH_2COOH]$, AND K_a for bromoacetic acid.

5. Calculate the pH AND percent ionization of a 0.050 M butanoic acid solution, $HC_4H_7O_2$, $K_a = 1.5 \times 10^{-5}$.

6. Calculate the pH of a 5.0 M H_3PO_4 solution and the equilibrium concentrations of the species H_3PO_4, $H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-} ($K_{a1} = 7.5 \times 10^{-3}$; $K_{a2} = 6.2 \times 10^{-8}$; $K_{a3} = 4.8 \times 10^{-13}$).

7. Rank the following species in order of *increasing acid strength*, and explain your ordering:

A. HIO_3, $HClO_3$, $HBrO_3$ _____

B. HOCl, HOI, HOBr _____

C. SeH_2, GeH_4, AsH_3 _____

D. CH_3CO_2H, FCH_2CO_2H, F_2CHCO_2H_____

8. A solution contains 45 mL of 0.100 M $CH_3COOH(aq)$, $K_a = 1.8 \times 10^{-5}$, and 55 mL of 0.100 M $NaCH_3CO_2(aq)$.

A. Determine the pH of this solution.
B. Determine the pH of this solution when 10.0 mL of 0.350 M NaOH(aq) is added.
C. Determine the pH of this solution when 20.0 mL of 0.200 M $HNO_3(aq)$ is added.

9. A 25.0 mL sample of 0.035 M benzoic acid, $HC_7H_5O_2$, is titrated with 0.099 M NaOH solution. The K_a of benzoic acid is 6.3×10^{-5}.

A. What is the pH, pOH, and $[H_3O^+]$ of the benzoic acid solution prior to the titration?
B. What is the pH of the solution when 15.0 mL of 0.099 M NaOH solution is added to the original sample?
C. What is the pH of the solution at the half-way point of the titration?
D. What is the pH of the solution at the equivalence point of the titration?
E. What is the pH of the solution when 35.0 mL of 0.099 M NaOH solution is added to the original sample?
F. Which of the following would be the best indicator to use for this titration? Justify your answer.

Methyl red	$K_a = 1 \times 10^{-5}$
Cresol red	$K_a = 1 \times 10^{-8}$
Alizarin yellow	$K_a = 1 \times 10^{-11}$

10. At 25 ºC, the value of K_{sp} for $PbCl_2(s)$ is 1.6×10^{-5}, and the value of K_{sp} for $AgCl(s)$ is 1.8×10^{-10}.

A. If 60.0 mL of 0.0400 M NaCl(aq) is added to 60.0 mL of 0.0300 M $Pb(NO_3)_2(aq)$, will a precipitate form? Assume that volumes are additive. Show calculations to support your answer.

B. Calculate the equilibrium value of $[Pb^{+2}(aq)]$ in a 1.00 L saturated $PbCl_2$ solution to which 0.250 mole of NaCl(s) has been added. Assume no volume change occurs.

C. If 0.100 M NaCl(aq) is slowly added to a beaker containing both 0.120 M $AgNO_3(aq)$ and 0.150 M $Pb(NO_3)_2(aq)$ at 25 ºC, which will precipitate first, AgCl(s) or $PbCl_2(s)$? Show calculations to support your answer.

11. Calculate the molar solubility of lead(II) chloride ($K_{sp} = 1.6 \times 10^{-5}$) in 0.050 M $CaCl_2(aq)$.

12. The solubility of $Mg(OH)_2(s)$ in a particular buffer solution is 0.65 g/L. What must be the pH of the buffer solution? K_{sp} of $Mg(OH)_2(s)$ is 1.8×10^{-11}.

13. What minimum concentration of aqueous ammonia would be needed to dissolve 1.00 g of silver chloride and keep it in solution. The volume of the solution is to be 200 mL. The overall reaction is

$$\mathbf{AgCl\ (s)\ +\ 2NH_3\ \rightarrow\ Ag(NH_3)_2^{+}\ +\ Cl^{-}}$$

The solubility product of silver chloride is 1.7×10^{-10}, and the dissociation constant for $Ag(NH_3)_2^{+}$ is 6.0×10^{-8}.

14. Sodium thiosulfate ("hypo") is used as a fixer for photographic films and papers. The thiosulfate ion complexes with silver salts that are unexposed to light, and thus dissolves them. The exposed silver salts were "developed" previously, and at this "fixing" stage are metallic silver, which does **not** complex. If it is desired that a given fixing bath be capable of dissolving 40 g of silver chloride per liter, what must be

(a) the concentration of free thiosulfate ion when the solution has dissolved the 40 g of silver chloride per liter

(b) the initial concentration of thiosulfate ion before reaction with the silver chloride? The overall reaction to be considered is

$$\mathbf{AgCl\ (s)\ +\ 2S_2O_3^{2-}\ \rightarrow\ [Ag(S_2O_3)2]^{3-}\ +\ Cl\text{-}}$$

The solubility product for silver chloride is 1.7×10^{-10}, and the dissociation constant for the thiosulfatoargentate anion is 1×10^{-13}.