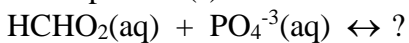


ACTIVITY/WORKSHOP on IONIC EQUILIBRIUM Name: \_\_\_\_\_

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



2. If pH = 6.6, what are the molar concentrations of  $\text{H}_3\text{O}^+(\text{aq})$  and  $\text{OH}^-(\text{aq})$  in the solution?

3. Lactic acid,  $\text{HC}_3\text{H}_5\text{O}_3$ , 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,  $\text{BrCH}_2\text{COOH}$ , is 13.2 percent ionized. Using this information, calculate  $[\text{BrCH}_2\text{COO}^-]$ ,  $[\text{H}^+]$ ,  $[\text{BrCH}_2\text{COOH}]$ , AND  $K_a$  for bromoacetic acid.

5. Calculate the pH AND percent ionization of a 0.050 M butanoic acid solution,  $\text{HC}_4\text{H}_7\text{O}_2$ ,  $K_a = 1.5 \times 10^{-5}$ .

6. Calculate the pH of a 5.0 M  $\text{H}_3\text{PO}_4$  solution and the equilibrium concentrations of the species  $\text{H}_3\text{PO}_4$ ,  $\text{H}_2\text{PO}_4^-$ ,  $\text{HPO}_4^{2-}$ , and  $\text{PO}_4^{3-}$  ( $K_{a1} = 7.5 \times 10^{-3}$ ;  $K_{a2} = 6.2 \times 10^{-8}$ ;  $K_{a3} = 4.8 \times 10^{-13}$ ).

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

A.  $\text{HIO}_3$ ,  $\text{HClO}_3$ ,  $\text{HBrO}_3$  \_\_\_\_\_

B.  $\text{HOCl}$ ,  $\text{HOI}$ ,  $\text{HOBr}$  \_\_\_\_\_

C.  $\text{SeH}_2$ ,  $\text{GeH}_4$ ,  $\text{AsH}_3$  \_\_\_\_\_

D.  $\text{CH}_3\text{CO}_2\text{H}$ ,  $\text{FCH}_2\text{CO}_2\text{H}$ ,  $\text{F}_2\text{CHCO}_2\text{H}$  \_\_\_\_\_

8. A solution contains 45 mL of 0.100 M  $\text{CH}_3\text{COOH}(\text{aq})$ ,  $K_a = 1.8 \times 10^{-5}$ , and 55 mL of 0.100 M  $\text{NaCH}_3\text{CO}_2(\text{aq})$ .

A. Determine the pH of this solution.

B. Determine the pH of this solution when 10.0 mL of 0.350 M  $\text{NaOH}(\text{aq})$  is added.

C. Determine the pH of this solution when 20.0 mL of 0.200 M  $\text{HNO}_3(\text{aq})$  is added.

9. A 25.0 mL sample of 0.035 M benzoic acid,  $\text{HC}_7\text{H}_5\text{O}_2$ , is titrated with 0.099 M  $\text{NaOH}$  solution. The  $K_a$  of benzoic acid is  $6.3 \times 10^{-5}$ .

A. What is the pH, pOH, and  $[\text{H}_3\text{O}^+]$  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  $\text{NaOH}$  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  $\text{NaOH}$  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  $K_a = 1 \times 10^{-8}$

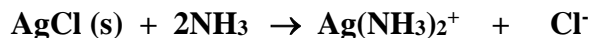
Alizarin yellow  $K_a = 1 \times 10^{-11}$

10. At 25 °C, the value of  $K_{sp}$  for  $PbCl_2(s)$  is  $1.6 \times 10^{-5}$ , and the value of  $K_{sp}$  for  $AgCl(s)$  is  $1.8 \times 10^{-10}$ .
- 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.
  - 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.
  - 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 °C, 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  $1.8 \times 10^{-11}$ .

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

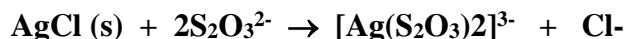


The solubility product of silver chloride is  $1.7 \times 10^{-10}$ , and the dissociation constant for  $Ag(NH_3)_2^+$  is  $6.0 \times 10^{-8}$ .

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



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