CH 223 Practice Problem Set #2

*This is a **practice problem set** and not the actual graded problem set that you will turn in for credit. Answers to each problem can be found at the end of this assignment.*

Covering: **Chapter Fourteen Part I** *and* **Chapter Guide Two**

Important Tables and/or Constants: The **Table of Acids and Bases for CH 223** *which follows problem set #2, and* **K_w = 1.00 x 10^{-14}** at 25 °C

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1. What are the products of each of the following acid–base reactions? Indicate the acid and its conjugate base, and the base and its conjugate acid.
   a. $HNO_3 + H_2O \rightarrow$
   b. $HSO_4^{-1} + H_2O \rightarrow$
   c. $H_3O^+ + F^{-1} \rightarrow$
2. Write balanced equations showing how the hydrogen oxalate ion, $HC_2O_4^{-1}$, can be both a Brønsted acid and a Brønsted base.
3. In each of the following acid–base reactions, identify the Brønsted acid and base on the left and their conjugate partners on the right.
   a. $C_5H_5N(aq) + CH_3CO_2H(aq) \rightleftharpoons C_5H_5NH^+(aq) + CH_3CO_2^-(aq)$
   b. $N_2H_4(aq) + HSO_4^-(aq) \rightleftharpoons N_2H_5^+(aq) + SO_4^{2-}(aq)$
   c. $[Al(H_2O)_6]^{3+}(aq) + OH^-(aq) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_2O(l)$
4. An aqueous solution has a pH of 3.75. What is the hydronium ion concentration of the solution? What is the hydroxide ion concentration of the solution? Is it acidic or basic?
5. What is the pH of a 0.0015 M solution of $Ba(OH)_2$?
6. Several acids are listed here with their respective equilibrium constants:

$$C_6H_5OH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_6H_5O^{-1}(aq)$$
$$K_a = 1.3 \times 10^{-10}$$
$$HCO_2H(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_2^{-1}(aq)$$
$$K_a = 1.8 \times 10^{-4}$$
$$HC_2O_4^{-1}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2O_4^{2-}(aq)$$
$$K_a = 6.4 \times 10^{-5}$$

   a. Which is the strongest acid? Which is the weakest acid?
   b. Which acid has the weakest conjugate base?
   c. Which acid has the strongest conjugate base?
7. Epinephrine hydrochloride has a pK_a value of 9.53. What is the value of K_a?
8. A weak base has $K_b = 4.7 \times 10^{-11}$. What is the value of K_a for the conjugate acid?
9. Which is the stronger of the following two acids?
   a. acetic acid, CH_3CO_2H, $K_a = 1.8 \times 10^{-5}$
   b. chloroacetic acid, $ClCH_2CO_2H$, pK_a = 2.87
10. Equal molar quantities of sodium hydroxide and sodium hydrogen phosphate (Na_2HPO_4) are mixed.
    a. Write the balanced, net ionic equation for the acid–base reaction that can, in principle, occur.
    b. Does the equilibrium lie to the right or left?
11. A 0.015 M solution of hydrogen cyanate, HOCN, has a pH of 2.67.
    a. What is the hydronium ion concentration in the solution?

b. What is the ionization constant, K_a, for the acid?

12. A 0.015 M solution of a base has a pH of 10.09.
    a. What are the hydronium and hydroxide ion concentrations of this solution?
    b. What is the value of K_b for this base?
13. Phenol (C_6H_5OH), commonly called carbolic acid, is a weak organic acid.

$$C_6H_5OH(aq) + H_2O(l) \rightleftharpoons C_6H_5O^{-1}(aq) + H_3O^{+}(aq) \qquad K_a = 1.3 \times 10^{-10}$$

    If you dissolve 0.195 g of the acid in enough water to make 125 mL of solution, what is the equilibrium hydronium ion concentration? What is the pH of the solution?
14. Calculate the pH of a 0.12 M aqueous solution of the base aniline, $C_6H_5NH_2$ (The K_b for aniline equals 4.0×10^{-10}).

$$C_6H_5NH_2(aq) + H_2O\ (l) \rightleftharpoons C_6H_5NH_3^{+1}(aq) + OH^{-1}(aq)$$

15. Calculate the hydronium ion concentration and pH in a 0.20 M solution of ammonium chloride, NH_4Cl.
16. Decide whether each of the following substances should be classified as a Lewis acid or a Lewis base.
    a. H_2NOH in the reaction: $H_2NOH(aq) + HCl(aq) \rightarrow [H_3NOH][Cl](aq)$
    b. $Fe^{2+}(aq)$
    c. CH_3NH_2
17. Given the following solutions:

a. 0.1 M NH_3	e. 0.1 M NH_4Cl
b. 0.1 M Na_2CO_3	f. 0.1 M $NaCH_3CO_2$
c. 0.1 M NaCl	g. 0.1 M $NH_4CH_3CO_2$
d. 0.1 M CH_3CO_2H	

    i. Which of the solutions are acidic?
    ii. Which of the solutions are basic?
    iii. Which of the solutions is most acidic?
18. The equilibrium constant for the reaction of formic acid and sodium hydroxide is 1.8×10^{10}. Confirm this value.

Answers to the Practice Problem Set:

1. *Answers:*
   a. HNO_3 + $H_2O \rightarrow$ H_3O^+ + NO_3^-
   acid A base B conjugate acid of B conjugate base of A
   b. HSO_4^- + $H_2O \rightarrow$ H_3O^+ + SO_4^{2-}
   acid A base B conjugate acid of B conjugate base of A
   c. $H_3O^+ + F^- \rightarrow$ HF + H_2O
   acid A base B conjugate acid of B conjugate base of A
2. *Answers:*
   Brønsted acid: $HC_2O_4^-(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + C_2O_4^{2-}(aq)$
   Brønsted base: $HC_2O_4^-(aq) + H_2O(\ell) \rightleftharpoons H_2C_2O_4(aq) + OH^-(aq)$
3. *Answers:*

	Brønsted acid	Brønsted base	conjugate base	conjugate acid
a.	CH_3CO_2H	C_5H_5N	$CH_3CO_2^-$	$C_5H_5NH^+$
b.	HSO_4^-	N_2H_4	SO_4^{2-}	$N_2H_5^+$
c.	$[Al(H_2O)_6]^{3+}$	OH^-	$[Al(H_2O)_5(OH)]^{2+}$	H_2O

4. $[H_3O^+] = 1.8 \times 10^{-4}$ M; $[OH^-] = 5.6 \times 10^{-11}$ M; acidic
5. pH = 11.48
6. a. HCO_2H; weakest acid = C_6H_5OH b. HCO_2H c. C_6H_5OH
7. 3.0×10^{-10}
8. 2.1×10^{-4}
9. chloroacetic acid
10. a. $OH^-(aq) + HPO_4^{2-}(aq) \rightleftharpoons H_2O(\ell) + PO_4^{3-}(aq)$ b. right
11. a. 0.0021 M b. 3.6×10^{-4}
12. $[H_3O^+] = 8.1 \times 10^{-11}$ M; $[OH^-] = 1.2 \times 10^{-4}$ M b. 9.7×10^{-7}
13. $[H_3O^+] = 1.5 \times 10^{-6}$ M; pH = 5.83
14. pH = 8.84
15. $[H_3O^+] = 1.1 \times 10^{-5}$ M; pH = 4.98
16. a. Lewis base b. Lewis acid c. Lewis base
17. a. CH_3CO_2H and NH_4Cl b. NH_3, Na_2CO_3, and $NaCH_3CO_2$ c. CH_3CO_2H
18. *Answers:*

$HCO_2H(aq) + H_2O(\ell) \rightleftharpoons HCO_2^-(aq) + H_3O^+(aq)$ $K_a = 1.8 \times 10^{-4}$

$OH^-(aq) + H_3O^+(aq) \rightleftharpoons 2\ H_2O(\ell)$ $K = 1/K_w$

$HCO_2H(aq) + OH^-(aq) \rightleftharpoons H_2O(\ell) + HCO_2^-(aq)$ $K = (1.8 \times 10^{-4})/K_w = 1.8 \times 10^{10}$