

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 $K_w = 1.00 \times 10^{-14}$ at 25 °C

- 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.
 - $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow$
 - $\text{HSO}_4^- + \text{H}_2\text{O} \rightarrow$
 - $\text{H}_3\text{O}^+ + \text{F}^- \rightarrow$
- Write balanced equations showing how the hydrogen oxalate ion, HC_2O_4^- , can be both a Brønsted acid and a Brønsted base.
- In each of the following acid–base reactions, identify the Brønsted acid and base on the left and their conjugate partners on the right.
 - $\text{C}_5\text{H}_5\text{N}(\text{aq}) + \text{CH}_3\text{CO}_2\text{H}(\text{aq}) \rightleftharpoons \text{C}_5\text{H}_5\text{NH}^+(\text{aq}) + \text{CH}_3\text{CO}_2^-(\text{aq})$
 - $\text{N}_2\text{H}_4(\text{aq}) + \text{HSO}_4^-(\text{aq}) \rightleftharpoons \text{N}_2\text{H}_5^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$
 - $[\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons [\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- 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?
- What is the pH of a 0.0015 M solution of $\text{Ba}(\text{OH})_2$?
- Several acids are listed here with their respective equilibrium constants:
$$\text{C}_6\text{H}_5\text{OH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{C}_6\text{H}_5\text{O}^-(\text{aq})$$
$$K_a = 1.3 \times 10^{-10}$$
$$\text{HCO}_2\text{H}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{HCO}_2^-(\text{aq})$$
$$K_a = 1.8 \times 10^{-4}$$
$$\text{HC}_2\text{O}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{C}_2\text{O}_4^{2-}(\text{aq})$$
$$K_a = 6.4 \times 10^{-5}$$
 - Which is the strongest acid? Which is the weakest acid?
 - Which acid has the weakest conjugate base?
 - Which acid has the strongest conjugate base?
- Epinephrine hydrochloride has a pK_a value of 9.53. What is the value of K_a ?
- A weak base has $K_b = 4.7 \times 10^{-11}$. What is the value of K_a for the conjugate acid?
- Which is the stronger of the following two acids?
 - acetic acid, $\text{CH}_3\text{CO}_2\text{H}$, $K_a = 1.8 \times 10^{-5}$
 - chloroacetic acid, $\text{ClCH}_2\text{CO}_2\text{H}$, $pK_a = 2.87$
- Equal molar quantities of sodium hydroxide and sodium hydrogen phosphate (Na_2HPO_4) are mixed.
 - Write the balanced, net ionic equation for the acid–base reaction that can, in principle, occur.
 - Does the equilibrium lie to the right or left?
- A 0.015 M solution of hydrogen cyanate, HOCN , has a pH of 2.67.
 - What is the hydronium ion concentration in the solution?

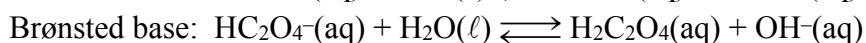
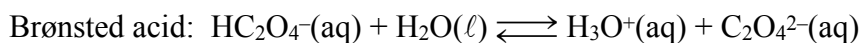
- b. What is the ionization constant, K_a , for the acid?
12. A 0.015 M solution of a base has a pH of 10.09.
- What are the hydronium and hydroxide ion concentrations of this solution?
 - What is the value of K_b for this base?
13. Phenol (C_6H_5OH), commonly called carboic acid, is a weak organic acid.
- $$C_6H_5OH(aq) + H_2O(l) \rightleftharpoons C_6H_5O^-(aq) + H_3O^+(aq) \quad K_a = 1.3 \times 10^{-10}$$
- 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}).
- $$C_6H_5NH_2(aq) + H_2O(l) \rightleftharpoons C_6H_5NH_3^+(aq) + OH^-(aq)$$
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.
- H_2NOH in the reaction: $H_2NOH(aq) + HCl(aq) \rightarrow [H_3NOH][Cl](aq)$
 - $Fe^{2+}(aq)$
 - 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 | |
- Which of the solutions are acidic?
 - Which of the solutions are basic?
 - 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. $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^-$
acid A base B conjugate acid of B conjugate base of A
- b. $\text{HSO}_4^- + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$
acid A base B conjugate acid of B conjugate base of A
- c. $\text{H}_3\text{O}^+ + \text{F}^- \rightarrow \text{HF} + \text{H}_2\text{O}$
acid A base B conjugate acid of B conjugate base of A

2. Answers:



3. Answers:

- | Brønsted acid | Brønsted base | conjugate base | conjugate acid |
|---|--------------------------------|---|-----------------------------------|
| a. $\text{CH}_3\text{CO}_2\text{H}$ | $\text{C}_5\text{H}_5\text{N}$ | CH_3CO_2^- | $\text{C}_5\text{H}_5\text{NH}^+$ |
| b. HSO_4^- | N_2H_4 | SO_4^{2-} | N_2H_5^+ |
| c. $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ | OH^- | $[\text{Al}(\text{H}_2\text{O})_5(\text{OH})]^{2+}$ | H_2O |
4. $[\text{H}_3\text{O}^+] = 1.8 \times 10^{-4} \text{ M}$; $[\text{OH}^-] = 5.6 \times 10^{-11} \text{ M}$; acidic
5. pH = 11.48
6. a. HCO_2H ; weakest acid = $\text{C}_6\text{H}_5\text{OH}$ b. HCO_2H c. $\text{C}_6\text{H}_5\text{OH}$
7. 3.0×10^{-10}
8. 2.1×10^{-4}
9. chloroacetic acid
10. a. $\text{OH}^-(\text{aq}) + \text{HPO}_4^{2-}(\text{aq}) \rightleftharpoons \text{H}_2\text{O}(\ell) + \text{PO}_4^{3-}(\text{aq})$ b. right
11. a. 0.0021 M b. 3.6×10^{-4}
12. $[\text{H}_3\text{O}^+] = 8.1 \times 10^{-11} \text{ M}$; $[\text{OH}^-] = 1.2 \times 10^{-4} \text{ M}$ b. 9.7×10^{-7}
13. $[\text{H}_3\text{O}^+] = 1.5 \times 10^{-6} \text{ M}$; pH = 5.83
14. pH = 8.84
15. $[\text{H}_3\text{O}^+] = 1.1 \times 10^{-5} \text{ M}$; pH = 4.98
16. a. Lewis base b. Lewis acid c. Lewis base
17. a. $\text{CH}_3\text{CO}_2\text{H}$ and NH_4Cl b. NH_3 , Na_2CO_3 , and NaCH_3CO_2 c. $\text{CH}_3\text{CO}_2\text{H}$

18. Answers:

