

Name: \_\_\_\_\_ Period: \_\_\_\_\_ Date: \_\_\_\_\_

### Chemistry 30 – Acid Equilibrium – Unit Homework

Topic	Textbook Reading	Textbook Questions
Properties of Acids and Bases Conjugate Acid/Base Pairs	Section 19.1 (595-601)	#2, 3
Strength of Acids and Bases Dissociation Constants	Section 19.2 (602-607)	#10, 11
pH and pOH	Section 19.3 (608-616)	#18-23
Neutralization and Titration	Section 19.4 (617-621)	19.1 #1 19.4 #29-32

### Properties of Acids and Bases

- List four characteristic properties of acids and of bases.
- Classify each of the following as either an acid or a base:
  - The substance has a bitter taste
  - $\text{H}_2\text{SO}_4$
  - litmus paper dipped in this turns red
  - reacts with active metals to produce hydrogen gas
  - KOH
  - $\text{NH}_3$
  - has a slippery feel
  - has a sour taste
  - a proton donor
  - a proton acceptor
- Copy the chart and fill it in with definitions.

	Acid	Base
Arrhenius		
Brønsted-Lowry		

- Which of the following could be considered Brønsted-Lowry bases?
  - $\text{Br}^-$
  - $\text{Li}^+$
  - $\text{H}_3\text{PO}_4$
  - $\text{NH}_4^+$
  - $\text{H}_2\text{O}$
  - $\text{NH}_2^-$

### Conjugate Acid-Base Pairs

- Identify the acid, base, conjugate acid and conjugate base for each of the following.
  - $\text{HClO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{ClO}_4^-(\text{aq})$
  - $\text{H}_2\text{SO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{HSO}_3^-(\text{aq})$
  - $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$
  - $\text{H}_2\text{S}(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{HS}^-(\text{aq})$
  - $\text{HSO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{SO}_3^{2-}(\text{aq})$
  - $\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$
  - $\text{HF}(\text{aq}) + \text{HSO}_3^-(\text{aq}) \rightleftharpoons \text{F}^-(\text{aq}) + \text{H}_2\text{SO}_3(\text{aq})$
  - $\text{HNO}_2(\text{aq}) + \text{HS}^-(\text{aq}) \rightleftharpoons \text{NO}_2^-(\text{aq}) + \text{H}_2\text{S}(\text{aq})$
- Complete the equation for the reaction of each of the following with water. Then:
  - Indicate whether the ion or molecule is an acid or base; and,
  - Indicate whether each reaction is explained by Arrhenius, Brønsted-Lowry, or both.
    - $\text{HI}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons$
    - $\text{HF}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons$
    - $\text{C}_2\text{H}_3\text{O}_2^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons$
    - $\text{CO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons$
    - $\text{O}^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons$

7. Define the term **amphoteric**. Give an example of an amphoteric compound.
8. Write the formula for the conjugate base of:
- $\text{H}_2\text{SO}_3$
  - $\text{HCO}_3^-$
  - $\text{NH}_4^+$
9. What are the conjugate bases of these acids?

original acid	conjugate base
$\text{HNO}_3$	
$\text{H}_2\text{O}$	
$\text{H}_3\text{O}^+$	
$\text{H}_2\text{SO}_4$	
$\text{HBr}$	
$\text{HCO}_3^-$	

10. What are the conjugate acids of these bases?

original base	conjugate acid
$\text{OH}^-$	
$\text{H}_2\text{O}$	
$\text{HCO}_3^-$	
$\text{SO}_4^{2-}$	
$\text{ClO}_4^-$	

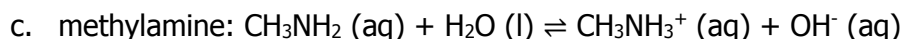
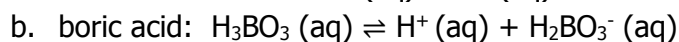
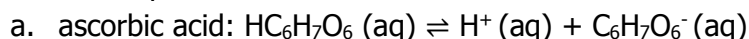
11. Write the formula for the conjugate acid of:
- $\text{H}_2\text{O}$
  - $\text{CO}_3^{2-}$
  - $\text{PH}_3$
12. Which of the following represent conjugate acid-base pairs?
- $\text{H}_2\text{O}, \text{H}_3\text{O}^+$
  - $\text{OH}^-, \text{HNO}_3$
  - $\text{H}_2\text{SO}_4, \text{SO}_4^{2-}$
  - $\text{HC}_2\text{H}_3\text{O}_2, \text{C}_2\text{H}_3\text{O}_2^-$

### Strength of Acids and Bases

13. What is the difference between a strong acid and a weak acid? Give an example of both.
14. Explain the difference between the terms "concentrated" and "dilute" with respect to both strong and weak acids.
15. Write a dissociation equation for each acid or base in an aqueous solution. Remember to use a single arrow ( $\rightarrow$ ) for strong acids and bases and a double arrow ( $\rightleftharpoons$ ) for weak acids and bases.
- $\text{HCl}$
  - $\text{NaOH}$
  - $\text{Ca}(\text{OH})_2$
  - $\text{HCN}$
  - $\text{H}_2\text{SO}_4$
  - $\text{HC}_2\text{H}_3\text{O}_2$
  - $\text{NH}_3$
16. Write balanced equations for:
- The dissociation of calcium hydroxide
  - The ionization of nitric acid
  - The ionization of propionic acid
  - The ionization of pyridine

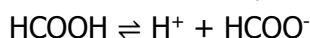
## K<sub>a</sub> and K<sub>b</sub>

17. Given the following balanced ionization reactions for the following weak acids and bases, write the K<sub>a</sub> or K<sub>b</sub> expressions for each.



18. Calculate [H<sup>+</sup>] for a 1.0 × 10<sup>-3</sup> M solution of hydrochloric acid.

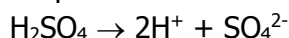
19. Calculate [H<sup>+</sup>] in a 0.20 M solution of formic acid. K<sub>a</sub> = 1.8 × 10<sup>-4</sup>



20. Ethylamine (C<sub>2</sub>H<sub>5</sub>NH<sub>2</sub>) is a weak base. Calculate [OH<sup>-</sup>] in a 2.32 × 10<sup>-3</sup> M solution if K<sub>b</sub> = 5.6 × 10<sup>-4</sup>.

21. Calculate [OH<sup>-</sup>] in a solution containing 100.0 g of potassium hydroxide in 2.50 L solution. Potassium hydroxide is a strong base.

22. A solution is prepared that contains 0.0445 mole of sulfuric acid in a total solution volume of 12.1 L. Sulfuric acid typically undergoes complete ionization according to the equation:



Calculate [H<sup>+</sup>]. Sulfuric acid is a strong acid.

23. Calculate the hydroxide ion concentration in a 0.045M solution of ammonia, NH<sub>3</sub>, a weak base with K<sub>b</sub> = 1.8 × 10<sup>-5</sup>.

## pH and pOH

24. Determine pH and pOH for each concentration.

a. [H<sup>+</sup>] = 0.023 M

b. [H<sup>+</sup>] = 6.6 × 10<sup>-6</sup> M

c. [OH<sup>-</sup>] = 0.0334 M

d. [OH<sup>-</sup>] = 9.01 × 10<sup>-4</sup> M

e. [H<sup>+</sup>] = 8.96 × 10<sup>-3</sup> M

25. Determine [H<sup>+</sup>] and [OH<sup>-</sup>] for each pH value.

a. pH = 2.5

b. pH = 11.3

c. pOH = 4.6

d. pOH = 8.7

e. pH = 7.65

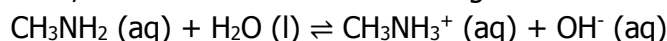
26. 4.52 g of calcium hydroxide, a strong base, is dissolved in 1.00 L of water. What is the pH of the resulting solution?

27. Methanoic acid (HCHO<sub>2</sub>) is a weak acid that undergoes the following ionization reaction:



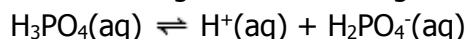
If 25.0 g of methanoic acid is dissolved to make 0.500 L of solution, what is the pH?

28. A weak base, methylamine, is dissolved in water according to the following dissociation reaction:



If 0.00355 moles of methylamine is present in 1.25 L of solution, what is the pH?

29. Phosphoric acid is a **weak** acid that undergoes the following ionization reaction:



If there is  $1.32 \times 10^{-2}$  mol of phosphoric acid present in 875 mL of solution, calculate the concentration of hydrogen ions,  $H^+$ , in solution.  $K_a$  for phosphoric acid is  $7.0 \times 10^{-3}$ .

30. A solution of acetic acid contains 12.0 g of  $HC_2H_3O_2$  in 500 mL of solution. Calculate  $[H^+]$ .
31. Why would the pH be different for a 0.05 M solution of HCl and a 0.05 M solution of acetic acid? What is the difference in pH?
32. Calculate the pH of a 0.00345 M solution of aniline,  $C_6H_5NH_2$ , a weak base.
33. Calculate the  $[H^+]$  in a solution in which  $[OH^-] = 2.0 \times 10^{-2}$  M. Is this solution acidic, neutral, or basic?
34. Find pH of each of the following. Identify each as an acidic, neutral, or basic.
  - a.  $[H^+] = 0.0015$  M
  - b.  $[H^+] = 5.0 \times 10^{-9}$  M
  - c.  $[OH^-] = 3.27 \times 10^{-4}$  M
  - d.  $[OH^-] = 1.00 \times 10^{-12}$  M
35. What is the pH, pOH,  $[H^+]$ , and  $[OH^-]$  for a  $3.2 \times 10^{-4}$  M solution of sodium hydroxide?
36. What is the pH, pOH,  $[H^+]$ , and  $[OH^-]$  for a  $9.20 \times 10^{-3}$  M solution of sulfuric acid?

### Neutralization

37. How many moles of NaOH are needed to completely neutralize 0.432 mol of  $H_2SO_4$ ?
38. How many moles of  $Ca(OH)_2$  are needed to completely neutralize 0.530 mol of  $H_3PO_4$ ?
39. It takes 38 mL of 0.75 M NaOH solution to completely neutralize 155 mL of a sulfuric acid solution ( $H_2SO_4$ ). What is the concentration of the  $H_2SO_4$  solution?
40. It takes 12.5 mL of a 0.30 M  $CH_3COOH$  solution to completely neutralize 285 mL of NaOH solution. What is the concentration of the NaOH solution?
41. It takes 50 mL of 0.500 M KOH solution to completely neutralize 125 mL of sulfuric acid solution. What is the pH of the sulfuric acid solution?
42. What is the pH of a NaOH solution if it takes 100.0 mL to neutralize 150.0 mL of 3.00 M  $H_2CO_3$  solution?
43. Titration reveals that 11.6 mL of 3.0 M sulfuric acid are required to neutralize the sodium hydroxide in 25.00 mL of NaOH solution. What is the molarity of the NaOH solution?
44. When 34.2 mL of a 1.02 M NaOH solution is added from a buret to 25.00 mL of a phosphoric acid solution that contains phenolphthalein, the solution changes from colorless to pink. What is the molarity of the phosphoric acid?