AMSAT Chem 1H Mr. Dehne

Name: ____________________________________

Date: ____________________

Per#:___

Acid/Base Topic#14

WS#1: Introduction to Acids and Bases

Name the following acids and bases. Classify as strong acid (SA), weak acid (WA), strong base (SB), or weak base (WB).

1. HBr (*aq*) ________hydrobromic acid______ _SA_
2. NaOH(*s*) _______sodium hydroxide________ _SB_
3. $HNO_2(aq)$ ______________________________ ____
4. $H_2SO_4(aq)$ ______________________________ ____
5. HCN(*aq*) ______________________________ ____
6. $CH_3NH_2(aq)$_______methyl amine_______ _WB_
7. $HNO_3(aq)$ ______________________________ ____
8. HI(*aq*) ______________________________ ____
9. $Ca(OH)_2(s)$ ______________________________ ____
10. $Sr(OH)_2(s)$ ______________________________ ____
11. $HClO_4(aq)$ ______________________________ ____
12. $NH_4OH(aq)$______________________________ ____
13. HF(*aq*) ______________________________ ____
14. CsOH(*s*) ______________________________ ____
15. $HClO_2(s)$ ______________________________ ____
16. HClO(*aq*) ______________________________ ____
17. RbOH(*s*) ______________________________ ____
18. KOH(*s*) ______________________________ ____
19. HCl(*aq*) ______________________________ ____
20. LiOH(*s*) ______________________________ ____
21. $Ba(OH)_2(s)$ ______________________________ ____
22. $HClO_3(aq)$ ______________________________ ____
23. $H_3PO_4(aq)$ ______________________________ ____
24. What is an acidic hydrogen? ____a hydrogen that can be donated to water_________
25. What is a binary acid? ____
26. What is an oxyacid? ____
27. What is a carboxylic acid? ____
28. What is an amine? ____
29. Which of the following compounds has an acidic hydrogen? HNO_3, CH_4, HBr, or H_2

Write an “A” if it is a property of an acidic solution, a “B” if it is a property of a basic solution, and “X” if it is a property of both.

30. ____ often feels smooth and slippery
31. ____ has a sour taste
32. ____ stings in open wounds
33. ____ typically reacts vigorously with metals
34. ____ has a bitter taste
35. ____ typically does not react with metals
36. ____ turns litmus paper from blue to red
37. ____ is an electrolyte
38. ____ often looks like pure water
39. ____ turns litmus paper from red to blue

WS#2: Acid-Base Theories

1. What is an Arrhenius definition of an acid? Base
2. What is the Bronsted-Lowry (BL) definition of an acid? Base?
3. Why might NH_3 not be considered a base according to the Arrhenius definition?
4. Why is the Bronsted-Lowry definition of acids and bases more encompassing than the Arrhenius definition?
5. Why is the H^+ ion the same as a proton?

According to Bronsted-Lowry (BL) theory, an acid is a proton (H^+) donor, and a base is a proton acceptor.

H^+

Example: $HCl(l) + OH^-(aq) \rightarrow Cl^-(aq) + H_2O(l)$

acid base CB CA

The HCl acts as an acid, the OH^- as a base. This reaction is reversible in that the H_2O can give back the proton to the Cl^-.

Label the Bronsted-Lowry acid, base, conjugate acid, and conjugate base in the following reactions and show the direction of proton transfer.

6. $H_2O(l) + H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$
7. $H_2SO_4(aq) + OH^-(aq) \leftrightarrow HSO_4^-(aq) + H_2O(l)$
8. $HSO_4^-(aq) + H_2O(l) \leftrightarrow SO_4^{-2}(aq) + H_3O^+(aq)$
9. $OH^-(aq) + H_3O^+(aq) \leftrightarrow H_2O(l) + H_2O(l)$
10. $NH_3(aq) + H_2O(l) \leftrightarrow NH_4^+(aq) + OH^-(aq)$
11. $HNO_2(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + NO_2^-(aq)$
12. $HCN(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + CN^-(aq)$
13. $NH_3(aq) + HF(aq) \leftrightarrow NH_4^+(aq) + F^-(aq)$
14. $ClO^-(aq) + H_2O(l) \leftrightarrow OH^-(aq) + HClO(aq)$
15. $CH_3NH_3^+(aq) + H_2O \leftrightarrow H_3O^+(aq) + CH_3NH_2(aq)$
16. Which is a stronger base, HSO_4^- or $H_2PO_4^-$? ___________
17. Which is a weaker base, Cl^- or NO_2^-? ___________

In the exercise, Bronsted-Lowry acids and bases, it was shown that after an acid has given up its proton; it is capable of getting back that proton and acting as a base. Conjugate base s formed after the acid gives up a proton.
Stronger acids produce weaker conjugate bases. Weaker acids produce stronger conjugate bases.

Conjugate Pairs

	Acid	Base	Equation
18.	H_2SO_4	HSO_4^{1-}	$H_2SO_4 \leftrightarrow H^+ + HSO_4^{1-}$
19.	H_3PO_4		
20.		F^-	
21.		NO_3^-	
22.	$H_2PO_4^{1-}$		
23.	H_2O		
24.		SO_4^{2-}	
25.	HPO_4^{2-}		
26.	NH_4^+		
27.		H_2O	

electrolyte   acid-base indicator   neutralization reaction   salt   hydronium ion   amphoteric   conjugate

28. An ionic compound that forms from an acid-bases neutralization reaction is a(n) ________________________.
29. A(n) ___________________ is a substance that conducts electricity.
30. The chloride ion (Cl^-) is the __________________ base of hydrochloric acid (HCl).
31. The formula H_3O^+ represents a(n) _______________________.
32. A(n) __________________________ turns one color in an acidic solution and another color in a basic solution.
33. The reaction between an acid and a base is called a(n) __________________________.
34. Since water can be either an acid or a base in a Bronsted-Lowry acid-base reaction, it is called a(n) _____ species.

WS#3: Acid and Base Equilibrium Expressions

1. Write the acid equilibrium constant (K_a) for the following acids.
   a. H_3PO_3(*aq*)   b. H_2CO_3(*aq*)   c. $H_2C_2O_4$(*aq*)   d. HOCN(*aq*)
2. Write the base equilibrium constant (K_b) for the following bases.
   a. NH_3(*aq*)   b. CH_3NH_2(*aq*)   c. $C_6H_5NH_2$(*aq*)   d. H_2NNH_2(*aq*)

WS#4: The Self-ionization of Water and pH

Matching

1. ____ self-ionization   a. has H_3O^+ concentration greater than $1x10^{-7}M$
2. ____ pure water   b. has H_3O^+ and OH^- concentrations of $1x10^{-7}M$
3. ____ ion product constant   c. has a pH greater than 7
4. ____ pH scale   d. describes this reaction: $H_2O+H_2O \leftrightarrow H_3O^++OH^-$
5. ____ acidic solution   e. has a pH=7; may contain ions other than H_3O^+ and OH^-
6. ____ basic solution   f. is equal to $1x10^{-14}$ at 25ºC
7. ____ neutral solution   g. describes the acidity or basicity of a solution
8. A chemist has a solution of unknown pH. Describe the most accurate way the pH can be determined.
9. What is an indicator? How can an indicator be used to measure the pH of a solution?

T or F, Correct if false.

10. In the reaction $H_2O + H_2O \leftrightarrow H_3O^+ + OH^-$, <u>products</u> are favored. ______________________
11. The ion product constant applies to <u>every water solution</u> at a given *T*. ______________________
12. An acidic solution contains <u>only H_3O^+ ions</u>. ______________________
13. A solution with a pH of 4 is <u>acidic</u>. ______________________
14. Indicators are made from <u>neutral solutions</u>. ______________________

WS#5: pH and pOH

The pH of a solution indicates how acidic or basic that solution is, in other words, the $[H_3O^+]$ in solution. The pH range is 0-6.9(acidic), 7 (neutral), and 7.1-14 (basic). Since $[H_3O^+]x[OH^-] = 1x10^{-14}$ @ 25ºC, if $[H_3O^+]$ is known, then the $[OH^-]$ can be calculated and vice versa. The formulas are pH = - log$[H_3O^+]$ and pOH = - log$[OH^-]$. So, if $[H_3O^+] = 1x10^{-6}$*M*, then pH = 6. Since the $[H_3O^+]$ is $1x10^{-6}$*M*, the $[OH^-]$ is equal to $1x10^{-14}$ divided by $1x10^{-6}$*M* which equals $1x10^{-8}$*M*. This gives a pOH value of 8. To check your answer use the formula, pH + pOH = 14.

	$[H_3O^+]$	pH	$[OH^-]$	pOH	acidic/basic/neutral
1.	$1x10^{-5}$ *M*	5	$1x10^{-9}$ *M*	9	acidic
2.		7			
3.			$1x10^{-4}$ *M*		
4.	$1x10^{-2}$ *M*				
5.				11	
6.		12			
7.			$1x10^{-5}$ *M*		
8.	$1x10^{-11}$ *M*				
9.				13	
10.		6			

WS#6: pH, pOH, $[H_3O^+]$, and $[OH^-]$

Solve for the unknown and determine whether the solution is acidic, neutral, or basic. Must show work.

1. Analysis of a sample of maple syrup reveals that the concentration of OH^- ions is $5.0x10^{-8}$*M*. What is the pH and pOH of this syrup? Is it acidic, neutral, or basic? (pH = 6.70, pOH = 7.30, acidic)
2. In a sample of bananas and water, it is found that $[H_3O^+] = 2.51x10^{-5}$M. What is the corresponding pH value? (Ans: pH = 4.600, acidic)
3. $[OH^-] = 7.94x10^{-12}$*M* in a sample of vinegar. What is the pH of the vinegar? (Ans: pH = 2.900, acidic)
4. A sample of human blood plasma is found to have a concentration of H_3O^+ ions of $3.72x10^{-8}$*M*. What is the pH of this sample? (Ans: pH = 7.430, basic)
5. In a sample of saturated magnesia, it is found that $[OH^-] = 3.22x10^{-4}$*M*. What is the pH and pOH of this sample? (Ans: pH = 10.508, pOH = 3.492, basic)
6. Tomatoes are found to have a hydronium ion (H_3O^+) concentration of $6.2x10^{-5}$*M*. What is the pH of these tomatoes? (Ans: 4.21)
7. A saturated solution of calcium carbonate has a hydroxide concentration of $2.44x10^{-4}$ *M*. What is the pH of this solution? (Ans: pH = 10.387, basic)
8. The hydronium concentration in a urine specimen is measured to be $6.3x10^{-6}$*M*. What is the pH of this solution? (Ans: pH = 5.20, acidic)
9. What is the pH of sour pickles if $[OH^-] = 1.6x10^{-10}$*M*? (Ans: pH = 4.20, acidic)
10. The hydroxide content of a popular soft drink is measured and found to be $4.11x10^{-9}$*M*. What is the pH of this soft drink? (Ans: pH = 5.614, acidic)
11. A sample of apple juice has a pH of 2.94.
    a. Determine the pOH
    b. What is the hydronium ion concentration in the juice?
    c. What is the hydroxide ion concentration in the juice?
    (Ans: (a) 11.06 (b) $1.1x10^{-3}$*M* (c) $8.7x10^{-12}$*M*)
12. A solution of baking soda has a pOH of 5.70.
    a. Determine the pH.
    b. What is the hydronium ion concentration in baking soda solution?
    c. What is the hydroxide ion concentration in baking soda solution?
    (Ans: (a) 8.3 (b) $5.0x10^{-9}$*M* (c) $2.0x10^{-6}$*M*)

WS#7: Acid-Base Reactions

1. Calculate the pH and pOH for the following strong acids.
   a. 0.01*M* HCl(*aq*) (Ans: pH = 2.0)
   b. 0.030*M* HBr(*aq*) (Ans: pH = 1.52)
   c. 0.020*M* H_2SO_4(*aq*) (Ans: pH = 1.40)
2. Calculate the pH and pOH for the following strong bases.
   a. 0.50*M* HNO_3 (Ans: pH = 0.30)
   b. 0.0010*M* NaOH (Ans: pH = 11.0)
   c. 0.50*M* $Ca(OH)_2$ (Ans: pH = 14.00)
3. Calculate the pH and pOH for the following weak acids and bases based on their ionization in water.
   a. 2.0*M* $HC_2H_3O_2/CH_3COOH$(*aq*) (Assume 5.0% dissociation) (Ans: pH = 1.00)
   b. 3.0*M* HF(*aq*) (Assume 10.0% dissociation)(Ans: pH = 0.52)
   c. 5.0*M* HNO_2(*aq*) (Assume 1.0% dissociation) (Ans: pH = 1.30)
   d. 0.150*M* NH_3(*aq*) (Assume 4.8% dissociation) (Ans: pH = 11.86)

Predict the products and write a balanced molecular equation.

4. HBr(*aq*) + Na_2S(*aq*) →
5. CsOH(*aq*) + NH_4I(*aq*) →
6. $HClO_4$(*aq*) + $CaCO_3$ →
7. $Ba(OH)_2$(*aq*) + NH_4Br(*aq*) →
8. HNO_2(*aq*) + RbOH(*aq*) →
9. HI(*aq*) + ZnS(*aq*) →

WS#8: Acid-Base Titration

To determine the concentration of an acid (or base), we can react it with a base (or acid) of known concentration until it is completely neutralized. This point of exact neutralization, known as the endpoint, is noted by the change in color of the indicator**.** Must show work.

$N_A \times V_A = N_B \times V_B$ where *N* = normality, *V* = volume

1. A 25.0mL sample of HCl was titrated to the endpoint with 15.0mL of 2.0*N* NaOH. What was the normality of the HCl? What was its molarity? (Ans: 1.2*N* and 1.2*M*)
2. A 10.0mL sample of H_2SO_4(*aq*) was exactly neutralized by 13.5mL of 1.0*M* KOH(*aq*). What is the molarity of the H_2SO_4(*aq*)? What is the normality? (Ans: 0.675*M* and 1.35*N*)
3. How much 1.5*M* NaOH(*aq*) is necessary to exactly neutralize 20.0mL of 2.5*M* H_3PO_4(*aq*)? (Ans: 1.0×10^2mL)
4. How much of 0.50*M* HNO_3(*aq*) is necessary to titrate 25.0mL of 0.050*M* $Ca(OH)_2$(*aq*) solution to the endpoint? (Ans: 5.0mL)
5. What is the molarity of a NaOH(*aq*) solution if 15.0mL is exactly neutralized by 7.5mL of a 0.02*M* $HC_2H_3O_2$(*aq*) solution? (Ans: 0.010*M*)
6. What is the molarity of an H_2SO_4(*aq*) solution if 45ml of the solution needed 75mL of 0.10*M* NaOH(*aq*) to neutralize it? (Ans: 0.083*M*)
7. A 150.mLsolution of 0.250*M* $Ca(OH)_2$(*aq*) was titrated with 0.50*M* HBr(*aq*). How much HBr(*aq*) was needed to neutralize the $Ca(OH)_2$(*aq*) solution? (Ans: 150mL)
8. What is the molarity of a 175mL sample of phosphoric acid, H_3PO_4(*aq*). The H_3PO_4(*aq*) solution was neutralized with 80.0mL of a 0.300*M* solution of $Ca(OH)_2$(*aq*). (Ans: 0.0914*M*)