**WS #1 Conjugate Acid-Base Pairs**

1.  List five properties of acids that are in your textbook.

**Acids conduct electricity, taste sour, neutralize bases, change the color of indicators, and react with some metals to produce hydrogen.**

2.  List five properties of bases that are in your textbook.

**Bases conduct electricity, taste bitter, neutralize acids, change the color of indicators, and feel slippery.**

3. Make some brief notes on the commercial acids: HCl and H2SO4(p 112).

**HCl** - five common use

**H2SO4**- five common use

4. Make some brief notes on the commercial base NaOH - five common uses.

5. Describe the difference between a concentrated and dilute acid (hint: concentration refers to the molarity). Describe their relative conductivities.

**Concentrated means relatively high molarity and dilute means relatively low molarity.**

6. Describe the difference between a strong and weak acid (p 121-124). Use two examples and write equations to support your answer. Describe their relative conductivities.

**A strong acid completely ionizes and a weak acid partially ionizes.**

7. Describe a situation where a strong acid would have the same conductivity as a weak acid (hint: think about concentration).

**A weak acid could have a high molarity and the strong acid could have a low molarity.**

Complete this worksheet for next period. Read pages 107-126 for homework.

Complete each acid reaction. Label each reactant or product as an acid or base. The first on is done for you.

1.         HCN                +          H2O                             ⇄                    H3O+      +        CN-

            Acid                            Base                                                    Acid                Base

2.         H3C6O7            +          H2O                             ⇄                    **H2C6O7-+H3O+**

**acid**                             **base**                                                    **base                acid**

3.         H3PO4              +          H2O                             ⇄                    **H2PO4-+H3O+**

**acid                             base                                                    base                acid**

4.         HF                   +          H2O                             ⇄                    **F-+H3O+**

**acid                             base                                                    base                acid**

5.         H2CO3             +          H2O                             ⇄                    **HCO3-+H3O+**

**acid                             base                                                    base                acid**

6.         NH4+                +          H2O                             ⇄                    **NH3+H3O+**

**acid                             base                                                    base                acid**

7.         CH3COOH  +              H2O                             ⇄                    **CH3COO-+H3O+**

**acid**                             **base                                                    base                            acid**

8.         HCl     +                      H2O                             →                    **Cl-+H3O+**

**acid**                             **base                                                    base                acid**

9.         HNO3  +                      H2O                             →                    **H3O++NO3-**

**acid**                             **base                                                    acid                 base**

Write the equilibrium expression (Ka) for the first seven above reactions.

10.       Ka =    **[H3O+] [ CN-]**                                     14. Ka =          **[H3O+] [HCO3-]**

                             **[HCN]                                                                         [H2CO3]**

**11.       Ka =    [H3O+] [H2C6O7-]                              15. Ka =          [H3O+] [NH3]**

**[H3C6O7]                                                                    [NH4+]**

12.       Ka =    **[H3O+] [H2PO4-]**                                16. Ka =          **[H3O+] [CH3COO-]**

                               **[H3PO4]**                                                                   **[CH3COOH]**

13.       Ka =    **[H3O+] [F-]**

                            **[HF]**

17. Which acids are strong? **The six on the top of the acid chart are strong.**

18. What does the term strong acid mean? **They complete ionization into ions. Such as:  HCl  + H2O   → Cl-+H3O+**

19. Why is it impossible to write an equilibrium expression for a strong acid?         **Ka =**             **[H3O+] [Cl-]**

**[HCl] is equal to zero and in math numbers divided by zero are undefined.**                         **[HCl]**

20. Which acids are weak?

**All acids listed on the acid chart below the top six.**

23. What does the term weak acid mean?

**Incomplete ionization. Such as:  HF  + H2O   ⇄ F-+H3O+**

24. Explain the difference between a strong and weak acid in terms of electrical conductivity.

**A strong acid is a good conductor. A weak acid conducts but not so good.**

Acid                Conjugate Base                       Base                Conjugate Acid

14.       HNO2             **NO2-**                           15.       HCOO-            **HCOOH**

16.       HSO3-              **SO32-**                           17.       IO3-                  **HIO3**

18.       H2O2                **HO2**-                            19.       NH3                 **NH4+**

20.       HS-                  **S2-**                                21.       CH3COO-        **CH3COOH**

22.       H2O                 **OH-**                             23.       H2O                 **H3O+**

Define:

22. Bronsted acid- **a proton donor**

23. Bronsted base- **a proton acceptor**

24. Arrhenius acid- **a substance that ionizes in water to produce H+**

25. Arrhenius base- **a substance that ionizes in water to produce OH-**

26. List the six strong acids.**HCLO4  HI        HBr         HCl             HNO3              H2SO4**

27. Rank the acids in order of decreasing strength.

**HCl                 HSO4-H3PO4HFH2CO3            H2S**

28. What would you rather drink vinegar or hydrochloric acid? Explain.

**Vinegar. It is a weak acid and produces much less H30+ ion which is the corrosive part of an acid.**

**Making a Universal Indicator Lab Activity**

Mix the following indicators in a 50 mL beaker. Stir with an eyedropper.

**Yamada’s Universal Indicator**

5 drops thymol blue

8 drops methyl orange

5 drops phenolphthalein

10 drops bromothymol blue

20 drops of water

**Part 1.** In a spot plate add two drops of each buffer solution to a cell. Add one drop of Yamada’s indicator to each. Record each colour on another lab sheet by colouring the cell the same colour. Make sure you are accurate because you will use this information for future labs and projects.

<---------- Acid Strength Increases ------        Neutral    ----Base Strength Increases ------->

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| pH = 1 | pH = 3 | pH = 5 | pH = 7 | pH = 9 | pH =11 | pH = 13 |
|  |  |  |  |  |  |  |

**Part 2.**Test a drop of HCl, CH3COOH, NaOH, NH3, NaHCO3, H2CO3 and NaCl solution for conductivity. Test with your Universal Indicator. Record the pH of each. Test with your Universal Indicator. Explain your results with what you know about acids and bases. Classify each as a strong or weak acid or base or neutral, acidic, or basic salt. Write an equation for each to show how they ionize in water using the Bronsted (Chemistry 12) definition of an acid.

Wash and dry your acetate.

Wash and return your eyedropper.

Wash and return your beaker.

Wash your hands.

**Results**

Compound                   Conductivity                pH                   Classification

HCl                             **good                            1                      strong acid**

CH3COOH                  **ok                                3                      weak acid**

NaOH                          **good                            13                    strong base**

NH3                             **ok                                11                    weak base**

NaHCO3                      **good                            11                    weak base**

H2CO3                         **ok                                3                      weak acid**

NaCl                            **good                            7                      neutral salt**

**WS # 2 Conjugate Acid-Base Pairs**

Complete each reaction. Label each reactant or product as an acid or base.

1.         HCN                +     H2O                      ⇄        **H3O+               +          CN-**

2.         HCl                 +     H2O                      ⇄        **H3O+               +          Cl-**

3.         HF                   +     H2O                      ⇄        **H3O+               +          F-**

4.         F-                     +     H2O                      ⇄        **HF                   +          OH-**

5.         HSO4-              +   H2O                        ⇄        **H3O+               +          SO42-**

            (acid)

6.         NH4+                +     H2O                      ⇄        **H3O+               +          NH3**

7.         HPO42-             +     H2O                      ⇄        **H2PO4-                        +          OH-**

             (base)

Acid                            Conjugate Base                                   Base              Conjugate Acid

8.         HCO3-              **CO32-**                                      9.         CH3COO-        **CH3COOH**

10.       HPO4-2             **PO43-**                                       11.       IO3-                  **HIO3**

12.       H2O                 **OH-**                                         13.       NH2-                **NH3**

14.       HS-                  **S2-**                                            15.       C2H5SO73-        **HC2H5SO72-**

16.       Circle the strong bases.

            Fe(OH)3                      **NaOH**                        **CsOH**                        **KOH**

            Zn(OH)2                      **Sr(OH)2**                      **Ba(OH)2**                     **Ca(OH)2**

17.       Rank the following acids from strongest to weakest.

            H2S                  CH3COOH                  H2PO4-             HI                    HCl                 HF

**5                      4                                  6                      1                      1                      3**

18.       Rank the following bases from the strongest to weakest.

            H2O                 F-                     NH3                 SO32-                HSO3-              NaOH

**6                      4                      2                      3                      5                      1**

19.       i)  Write the reaction of H3BO3 with water (remove one H+ only because it is a weak acid).

**H3BO3  +     H2O        ⇄        H2BO3-+H3O+**

            ii) Write the Ka expression for the above.

**[H3O+]         [H2BO3-]**

**Ka =                        [H3BO3]**

            iii) What is the ionization constant for the acid (use your table).  **Ka = 7.3   x 10-10**

20.       List six strong acids.   **HClO4             HI           HBr              HCl                 HNO3              H2SO4**

21.       List six strong bases.  **NaOH              KOH               LiOH              RbOH             CsOH             Ba(OH)2**

22.       List six weak acids in order of decreasing strength (use your acid/base table).

**HIO3               H2C2O4           H2SO3             HSO4-             H3PO4             HNO2**

23.       List six weak bases in order of decreasing strength (use your acid/base table).

**PO43-               CO32-              CN-                  NH3                 H2BO3-            HS-**

**WS # 3 Using Acid Strength Tables**

Acid-base reactions can be considered to be a competition for protons. A stronger acid can cause a weaker acid to act like a base. Label the acids and bases. Complete the reaction. State if the reactants or products are favoured.

**1.         HSO4-             +          HPO42-            ⇄        SO42-+        H2PO4-**

**Acid                            Base                            Base                Acid**

**Products are favoured as HSO4-is a stronger acid than H2PO4-**

**2.         HCN               +          H2O                ⇄        H3O+    +         CN-**

**Acid                            Base                            Acid                Base**

**Reactants are favoured as H3O+  is a stronger acid than HCN.**

**3.         HCO3-             +          H2S                 ⇄        H2CO3+       HS-**

**Base                            Acid                            Acid                Base**

**Reactants are favoured as H2CO3is a stronger acid than H2S**

**4.         HPO42-            +          NH4+⇄        H2PO4-+     NH3**

**Base                Acid                            Acid                Base**

**Reactants are favoured as H2PO4-is a stronger acid than NH4+**

5.         **NH3                 +          H2O                ⇄        NH4++          OH-**

**Base                            Acid                            Acid                            Base**

**Reactants are favoured as OH-is a stronger base than NH3**

6.         **H2PO41-+NH3⇄        HPO42-          +            NH4+**

**Acid                            Base                            Base                            Acid**

**Products are favoured as NH3 is a stronger base than HPO42-**

7.         **HCO3-             +          HF                   ⇄        H2CO3                        +          F-**

**Base**                            **Acid                            Acid                            Base**

**Products are favoured as HF is a stronger acid than H2CO3**

8. Complete each equation and indicate if reactants or products are favoured. Label each acid or base.

**HSO4- +   HCO3-⇄   H2CO3     +          SO42-                           products are favoured since**

**H2PO4-+   HC03⇄   HPO42-     +          H2CO3      reactants are favoured since**

**HS03-+   HPO42-⇄   H2PO4-     +          SO32-                           products are favoured since**

**NH3+   HC2O4-⇄   NH4+        +          C2O42-                         products are favoured since**

9.Explain why HF(aq)is a better conductor than HCN(aq).

**HF is a stronger acid and creates more ions.**

10.Which is a stronger acid in water, HCl or HI? Explain!

**Both are strong acids and have the same strength as both completely ionize to from H+.**

11.  State the important ion produced by an acid and a base.

**Acid: H+  or H3O+      Base: OH-**

12.  Which is the stronger base? Which produces the least OH-?

**F- is the weaker base and produces the least OH-              CO3-2 is the stronger base**

13.  Define a Bronsted/Lowry acid and base.

**An acid is a proton donor and a base is a proton acceptor.**

14.  Define an Arrhenius acid and base.

**An acid ionizes in water to produce H+ and a base ionizes in water to produce OH-.**

15.  Complete each reaction and write the equilibrium expression.

**HF + H2O       ⇄       H3O+    +   F-                            Ka=      [ H3O+][ F-]                Kb=      [HF][ OH-]**

**F- + H2O         ⇄        HF    +   OH-                                            [HF]                                             [F-]**

16.  **H2SO4 + 2NaOH             →   Na2SO4    +    2HOH**

17.  Define conjugate pairs.

**Acid base pairs that differ by one proton.**

18. Give conjugate acids for:              HS-,     NH3,    HPO4-2,            OH-,                 H2O,                NH3,      CO3-2

**H2S     NH4+   H2PO4-                        HOH               H3O+               NH4+   HCO3-**

19.Give conjugate bases for:              NH4+,   HF,      H2PO4-,            H3O+,               OH-,                 HCO3-,             H2O

**NH3F-         HPO4-2HOH               O2-                   CO3-2OH-**

**WS # 4 Acid and Basic Anhydrides**

1. What is the strongest acid that can exist in water? Write an equation to show how a stronger acid would be reduced in strength by the leveling effect of water.

2. What is the strongest base that can exist in water? Write an equation to show how a stronger base would be reduced in strength by the leveling effect of water.

3. List three strong acids and three strong bases.

4. Rank the acids in decreasing strength:

            HClO4     Ka is very large            HClO3        Ka=1.2x10-2

HClO2        Ka=8.0x10-5                  HClO         Ka=4.4x10-8

5. For an oxy acid what is the relationship between the number of O’s and acid strength? (Compare H2S04and H2S03)

6.Which acid is stronger?                    HI03 or HIO2

7.Which produces more H30+?            H2CO3or HS04-

8.Which produces more OH-?             F-or HC03-

9.Which conducts better NH3 or NaOH (both .1M)? Why?

10.Which conducts better HF or HCN (both .1M)? Why?

11. Compare and contrast a strong and weak acid in terms of degree of ionization, size of ka, conductivity, and concentration of H+.

Classify each formula as an acid anhydride, basic anhydride, strong acid, weak acid, strong, or weak base. For each formula write an equation to show how it reacts with water. For anhydrides write two equations.

Formula           Classification              Reaction

12. Na2O         \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13. CaO           \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. SO3            \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15. CO2           \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

16. SO2            \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

17. HCl           \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

18. NH3           \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

19. NaOH         \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

20. HF             \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

21. H3PO4        \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**WS # 5     Hydrolysis of Salts and Reactions of Acids and Bases**

Describe each as an acid, base, neutral salt, acidic salt, or basic salt. For each salt write a parent acid-base formation equation, dissociation equation, and hydrolysis equation (only for acidic and basic salts). For acids and bases write an equation to show how each reacts with water.

1. **NaHCO3**                 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. AlCl3                       \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. NaC6H5O                      \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Co(NO3)3                      \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Na2CO3                   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. H2C2O4                   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. NH3                        \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. KCl                          \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. HNO3                      \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. RbOH                    \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**WS # 6     Hydrolysis of Salts and Reactions of Acids and Bases**

Describe each as an acid, base, neutral salt, acidic salt, or basic salt. For each salt write a parent acid-base formation equation, dissociation equation, and hydrolysis equation (only for acidic and basic salts). For acids and bases write an equation to show how each reacts with water.

1. NH3                          \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. NaCl                        \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. HCl                          \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. NaCN             \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. NaOH            \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. FeCl3              \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7.  HI         \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. LiHCO3         \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. Fe(NO3)          \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. MgCO3                      \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

11.  H2S                     \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

12. HF               \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13. CaI2             \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. Be(OH)2      \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**⇄**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15. Ba(OH)2        \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**→**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_         

**WS # 7 Yamada’s Indicator Activity**

**Acid, Base  and Salt Lab**

**Purpose:**

1) To use Yamada’s Indicator to determine the pH of various acids, bases and salts.

2) To classify compounds as strong acids, weak acids, strong bases, weak bases, neutral salts, acid anhydrides, and basic anhydrides.

3) To write reactions for each compound to show how each ionizes, hydrolyzes or reacts with water.

**Procedure:**

1) To a cell in a spot plate add one drop of solution or a very tiny amount of solid. Write the formula of the compound in the data table.

2) Add two drops of Yamada’s Indicator. Record the pH of the compound.

3) Classify the compound as a strong acid, weak acid, strong base,   weak base, neutral salt, acid anhydride, or basic anhydride. Use the formula of the compound as well as the pH.

4) Write an equation to show the reaction of anhydrides with water, the hydrolysis of salts, or the ionization of acids or bases.

**Data**

1.         Formula of compound             **Fe(NO3)3**

pH                                           **2**

            Classification                          **acid salt**

            Reaction or reactions              **Fe(NO3)3        →        Fe+3   +            3NO3-**

**Fe(H2O)63+     ⇄        Fe(H2O)5(OH)2+        +   H+**

2.         Formula of compound             **NaCH3COO**

            pH                                           **10**

            Classification                          **basic salt**

            Reaction or reactions              **NaCH3COO**   **→        Na+   +             CH3COO-**

**CH3COO-+   H2O  ⇄ CH3COOH    +    OH-**

3.         Formula of compound             **K2HPO4**

            pH                                           **10**

            Classification                          **basic salt**

               Reaction or reactions                  **K2HPO4**                           **→          2K+   +                 HPO4-2**

**HPO4-2**            **+   H2O             ⇄          H2PO4-**            **+                   OH-**

4.         Formula of compound             **HCl**

            pH                                           **0**

            Classification                          **strong acid**

            Reaction or reactions              **HCl**                 **→          H+   +                   Cl-**

5.         Formula of compound             **Al2(SO4)3**

pH                                           **3**

            Classification                          **acid salt**

            Reaction or reactions              **Al2(SO4)3        →        2Al+3   +          3SO4-2**

**Al(H2O)63+      ⇄        Al(H2O)5(OH)2+         +   H+**

6.         Formula of compound             **Na2CO3**         

pH                                           **12**

            Classification                          **basic salt**

            Reaction or reactions              **Na2CO3          →        2Na+   +           CO3-2**

**CO3-2   +   H2O           ⇄        HCO3-  +        OH-**

7.         Formula of compound             **P2O5**

            pH                                           **2**

            Classification                          **acid anhydride**

            Reaction or reactions              **P2O5**    **+   H2O           →        H2P2O6**

**H2P2O6**                       **⇄        H+    +      HP2O6-**

8.         Formula of compound             **Cu(NO3)2**

            pH                                           **4**

            Classification                          **acid salt**

               Reaction or reactions                       **Cu(NO3)2        →        Cu2+   +           2NO3-**

**Cu(H2O)62+    ⇄      Cu(H2O)5(OH)+         +   H+**

9.         Formula of compound             **Fe2(SO4)3**

            pH                                           **3**

            Classification                          **acid salt**

            Reaction or reactions              **Fe2(SO4)3       →        2Fe+3   +          3SO4-2**

**Fe(H2O)63+     ⇄        Fe(H2O)5(OH)2+        +   H+**

10.       Formula of compound             **N2O5**

            pH                                           **0**

            Classification                          **acid anhydride**

            Reaction or reactions              **N2O5**   **+   H2O  →  H2N2O6**    **→**  **2HNO3**

**HNO3**     **→     H+    +      NO3-**

11.       Formula of compound             **Zn(OH)2**

            pH                                           **12**

            Classification                          **weak base**

            Reaction or reactions              **Zn(OH)2        ⇄        Zn+2    +          2OH-**

12.       Formula of compound             **KHSO4**

            pH                                           **2**

            Classification                          **acid salt**

            Reaction or reactions              **KHSO4**           **→        K+        +          HSO4-**

**HSO4-**             **⇄        H+        +          SO42-**

13.       Formula of compound             **NaHCO3**

            pH                                           **10**

            Classification                          **basic salt**

            Reaction or reactions              **NaHCO3**         **→        Na+      +          HCO3-**

**HCO3**- +  **H2O               ⇄     H2CO3  +       OH-**

14.       Formula of compound             **CaCO3**

            pH                                           **10**

            Classification                          **basic salt**

            Reaction or reactions              **CaCO3**            **→        Ca+2    +          CO3-2**

**CO3-2**  +  **H2O**                 **<⇄ HCO3-  +        OH-**

15.       Formula of compound             **CaO**

            pH                                           **12**

            Classification                          **basic anhydride**

            Reaction or reactions              **CaO     +         H2O   →  Ca(OH)2**

**Ca(OH)2        →        Ca+2    +          2OH-**

16.       Formula of compound             **Al2(SO4)3**

            pH                                           **3**

            Classification                          **acidic salt**

            Reaction or reactions              **Al2(SO4)3        →        2Al+3   +          3SO4-2**

**Al(H2O)63+      ⇄        Al(H2O)5(OH)2+         +   H+**

17.       Formula of compound             **NaCl**

            pH                                           **7**

            Classification                          **neutral salt**

            Reaction or reactions              **NaCl   →        Na+      +          Cl-**

**WS # 8 - pH and pOH Calculations**

Complete the chart:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | [H+] | [OH-] | pH | pOH | Acid/base/neutral |
| 1. | 7.00 x 10-3M | **1.43 x 10-12M** | **2.155** | **11.845** | **acid** |
| 2. | **1.14 x 10-13M** | 8.75 x 10-2M | **12.942** | **1.058** | **base** |
| 3. | **4.7x 10-8M** | **2.1 x 10-7M** | 7.33 | **6.67** | **base** |
| 4. | **1.0 x 10-10M** | **1.0 x 10-4M** | **10.00** | 4.00 | **base** |
| 5. | **1.0 x 10-7M** | **1.0 x 10-7M** | **7.00** | **7.00** | Neutral (2sig figs) |
| 6. | **5 x 10-4M** | **2 x 10-11M** | **3.3** | 10.7 | **acid** |
| 7. | **2.80 x 10-3M** | **3.57 x 10-12M** | 2.553 | **11.447** | **acid** |
| 8. | 5.0 x 10-10M | **2.0 x 10-5M** | **9.30** | **4.70** | **base** |
| 9. | **2.1 x 10-5M** | 4.7 x 10-10M | **4.67** | **9.33** | **acid** |

10.       Calculate the [H+], [OH-] , pH and pOH for a 0.20 M Ba(OH)2 solution.

**Ba(OH)2        ⇄        Ba+2     +          2OH-**

**0.20M                         0.20M             0.40M**

**[OH-] = 0.40 M          [H+]  =  2.5   x  10-14 M          pH    =   13.60      pOH    =  0.40**

11.       Calculate the [H+], [OH-], pH and pOH for a 0.030 M HCl solution.

**HCl →            H+        +          Cl-**

**0.030M                       0.030M**

**[H+] = 0.030M            [OH-]  =  3.3   x  10-13 M        pH    =   1.52      pOH    =  12.48**

  12.       Calculate the [H+], [OH-], pH and pOH for a 0.20 M NaOH solution.

**NaOH            →        Na+      +          OH-**

**0.20M                         0.20M             0.20M**

**[OH-] = 0.20 M          [H+]  =  5.0   x  10-14 M          pH    =   13.30      pOH    =  0.70**

   13.       300.0 mL of 0.20 M HCl is added to 500.0 mL of water, calculate the pH of the solution.

**HCl                 →        H+                    +          Cl-**

**300.0  x  0.20 M  =     0.075 M                      0.075 M                                  pH  =  -Log[H+]  =  1.12**

**800.0**

  14.       200.0 mL of 0.020 M HCl is diluted to a final volume of 500.0 mL with water, calculate the pH.

**HCl                 →        H+                    +          Cl-**

**200.0  x  0.020 M  =   0.0080 M                    0.0080 M                                pH  =  -Log[H+]  =  2.10**

**500.0**

15.         150.0 mL of 0.40 M Ba(OH)2 is placed in a 500.0 mL volumetric flask and filled to the mark with water, calculate the pH of the solution.

                                      Ba(OH)2          →        Ba2+                 +          2OH-

**150.0  x  0.40 M  =     0.12 M            0.12 M            0.24 M**

**500.0**

**pOH  =  -Log[OH-]  =  0.62               pH  =  14.00  -  pOH    =    13.38**

16.         250.0 mL of 0.20 M Sr(OH)2 is diluted by adding 350.0 mL of water, calculate the pH of the solution.

                                                  Sr(OH)2           →        Sr2+                  +          2OH-

**250.0  x  0.20 M  =     0.083 M                      0.083 M                      0.1667 M**

**600.0**

**pOH  =  -Log[OH-]  =  0.78               pH  =  14.00  -  pOH    =    13.22**

17.         Calculate the pH of a saturated solution of 0.40M Ba(OH)2 when 25 mL was added 25.0 mL of water.

**Ba(OH)2         D        Ba2+  +            2OH-**

**(25)0.40 M                  0.20 M 0.40 M**

**(50)**

**[OH-]              =  0.40**

**pOH    = 0.40**

**pH       = 13.60**

**WS # 9   pH Calculations for Weak Acids**

1.           Calculate the [H+], [OH-], pH, and pOH for 0.20 M HCN.

**HCN               D        H+        +          CN-**

**I             0.20 M            0                      0**

**C           x                                  x                      x**

**E           0.20  -  x                      x                      x**

**x2**

                                      **=    4.9  x  10-10**

**0.20  -  x**

**x    =    9.9 x 10-6  M**

**[H+] = 9.9 x 10-6  M                           [OH-] = 1.0 x 10-9  M                pH  =  5.00     pOH  =  9.00**

2.           Calculate the [H+], [OH-], pH, and pOH for 2.20 M HF.

**[H+] = 2.8 x 10-2  M                           [OH-] = 3.6 x 10-13  M               pH  =  1.56     pOH  =  12.44**

3.           Calculate the [H+], [OH-], pH, and pOH for 0.805 M CH3COOH.

**[H+] = 3.8 x 10-3  M                           [OH-] = 2.6 x 10-12  M               pH  =  2.42     pOH  =  11.58**

4.           Calculate the [H+], [OH-], pH, and pOH for 1.65 M H3BO3.

**[H+] = 3.5  x 10-5  M                          [OH-] = 2.9  x 10-10  M              pH  =  4.46 pOH  =  9.54**

**5.**Calculate the pH of a saturated solution of Mg(OH)2.

**Mg(OH)2        D        Mg2+  +           2OH-**

**x                                  x                      2x**

**Ksp  =  [Mg2+][OH-]2**

**5.6  x  10-12  =   4x3**

**[OH-]  =  2x  =  2.22  x  10-4 M**

**pH = 10.35**

6.           Calculate the pH of a 0.200 M weak diprotic acid with a Ka = 1.8  x  10-6.

**H2X                 D        H+        +         HX-                     Note- only lose one proton for any weak acid!!**

**I             0.200 M                      0                      0**

**C           x                                  x                      x**

**E           0.20  -  x                      x                      x**

**Small Ka approximation x = 0**

**x2**

**=    1.8  x  10-6**

**0.20**

**x    =    6.0 x 10-4  M**

**[H+] = 6.0 x 10-4  M                           [OH-] = 1.7 x 10-11  M               pH  =  3.22     pOH  =  10.78**

7.           350.0 mL of 0.20M Sr(OH)2 is diluted by adding 450.0 mL of water, calculate the pH of the solution.

                                                  Sr(OH)2           →        Sr2+                  +          2OH-

**350.0  x  0.20 M  =     0.0875 M                    0.0875 M                    0.175 M**

**800.0**

**pOH  =  -Log[OH-]  =  0.76               pH  =  14.00  -  pOH    =    13.24**

**WS # 10  pH Calculations for Weak Acids**

1. The pH of 0.20 M HCN is 5.00. Calculate the Ka for HCN. Compare your calculated value with that in the table.

**[H+]  =  10-pH  =  10-5.00  =  0.0000100 M**

**HCN               D        H+        +          CN-**

**I             0.20 M            0                      0**

**C           0.0000100 M              0.0000100 M              0.0000100 M**

**E           0.19999                       0.0000100 M              0.0000100 M**

**Ka =   (0.0000100)2             =    5.0 x 10-10**



**0.19999**

**Ka = 5.0 x 10-10**

2. The pH of 2.20 M HF is 1.56. Calculate the Ka for HF. Compare your calculated value with that in the table.

**Ka = 3.5 x 10-4**

3. The pH of 0.805 M CH3COOH is 2.42. Calculate the Ka for CH3COOH. Compare your calculated value with that in the table.

**Ka = 1.8 x 10-5**

4. The pH of 1.65 M H3BO3 is 4.46. Calculate the Ka for H3BO3. Compare your calculated value with that in the table.

**Ka = 7.3 x 10-10**

5.           The pH of a 0.10 M diprotic acid is 3.683, calculate the Ka and identify the acid.

**[H+]  =  10-pH  =  10-3.683  =  0.0002075 M**

**H2X                 D        H+        +          HX-                  Note a diprotic weak acid only loses one proton.**

**I             0.10 M            0                      0**

**C           0.0002075 M              0.0002075 M              0.0002075 M**

**E           0.09979                       0.0002075 M              0.0002075 M**

**Ka =   (0.0002075)2             =    4.3 x 10-7**

**0.09979**

**Ka = 4.3 x 10-7Carbonic acid             H2CO3                        Look up on Ka Table.**

6.           The pH of 0.20 M NH3 is 11.227; calculate the Kb of the Base.

**pOH    =   14.00    -   pH   =   2.773**

**[OH-]   =    10-pOH       =          0.001686 M**

**NH3     +          H2O    ⇄        NH4+               +          OH-**

**I           0.20 M                                    0                                  0**

**C         0.001686 M                            0.001686 M                0.001686 M**

**E         0.1983 M                                0.001686 M                0.001686 M**

**Kb=   (0.001686)2                =    1.4 x 10-5**

**0.1983**

7.           The pH of 0.40 M NaCN is 11.456; calculate the pH for the basic salt. Start by writing an equation and an ICE chart.

**pOH    =   14.00    -   pH   =   2.544**

**[OH-]   =    10-pOH       =          0.002858 M**

**CN-      +          H2O    ⇄        HCN               +          OH-**

**I           0.40 M                        0                                  0**

**C         0.002858 M                            0.002858 M                0.002858 M**

**E         0.3971 M                                0.002858 M                0.002858 M**

**Kb=   (0.002858)2                =    2.1 x 10-5**

**0.3971**

8.           The pH of a 0.10 M triprotic acid is 5.068, calculate the Ka and identify the acid.

**[H+]  =  10-pH  =  10-5.068  =  8.55  x  10-6 M**

**H3X                 D        H+                    +          H2X-                Note a triprotic weak acid only loses one proton.**

**I             0.10 M            0                                  0**

**C           8.55  x  10-6 M            8.55  x  10-6 M            8.55  x  10-6 M**

**E           0.10 M            8.55  x  10-6 M            8.55  x  10-6 M**

**Ka =   (8.55  x  10-6)2           =    7.3 x 10-10**

**0.10**

**Ka = 7.3 x 10-10Boric acid                   H3BO3            Look up on Ka Table.**

9.           How many grams of CH3COOH are dissolved in 2.00 L of a solution with pH = 2.45?

**[H+]     =          10-2.45  =          0.003548 M**

**CH3COOH     ­            ⇄        H+                    +          CH3COO-**

**I           x                                              0                                  0**

**C         0.003548 M                            0.003548 M                0.003548 M**

**E         x     -    0.003548 M                0.003548 M                0.003548 M**

**Keq                 =          [H+][CH3COO-]**

**[CH3COOH]**

**1.8  x  10-5       =          (0.003548)(0.003548)**

**[CH3COOH]**

**[CH3COOH]  =          0.6994 M                    2.00 L    x   0.6994 moles       x  60.0 g  =          84 g**

**1 L                              1 mole**

\* Use questions 1 to 4 from last assignment to mark questions 1 to 4.

**WS # 11        Kb For Weak Bases**

Determine the Kb for each weak base. Write the ionization reaction for each. Remember that Kw = Ka •Kb (the acid and base must be conjugates). Find the base on the right side of the acid table and use the Ka values that correspond. Be careful with amphiprotic anions!

1.         1. NaNO2  (the basic ion is NO2-)

2.

**Kb(NO2-)  =  Kw                    =          1.0  x  10-14**

**Ka(HNO2)                     4.6  x  10-4**

3.

**Kb = 2.2 x 10-11**

2.     2. KCH3COO (the basic ion is CH3COO-)      **Kb = 5.6 x 10-10**

3.     3. NaHCO3**Kb = 2.3 x 10-8**

4.   NH3**Kb = 1.8 x 10-5**

5.   NaCN        **Kb = 2.0 x 10-5**

6.   Li2HPO4**Kb = 1.6 x 10-7**

7.   KH2PO4**Kb = 1.3  x 10-12**

8.   K2CO3**Kb = 1.8 x 10-4**

9. Calculate the [H+], [OH-], pH, and pOH for 0.20 M H2CO3.

**[H+] = 2.9  x 10-4  M                          [OH-] = 3.4  x 10-11  M              pH  =  3.53               pOH  =  10.47**

10. The pH of 0.20 M H2CO3 is 3.53. Calculate the Ka for H2CO3. Compare your calculated value with that in the table.

**Ka = 4.4 x 10-7**

11. Calculate the [H+], [OH-], pH, and pOH for 0.10 M CH3COOH.

**[H+] = 1.3 x 10-3  M                           [OH-] = 7.5  x 10-12  M              pH  =  2.87               pOH  =  11.13**

12. The pH of 0.10 M CH3COOH is 2.87. Calculate the Ka.

**[H+]    =          10-2.87  =          0.001349 M**

**CH3COOH     ­            ⇄        H+                    +          CH3COO-**

**I           0.10 M                                    0                                  0**

**C         0.001349 M                            0.001349 M                0.001349 M**

**E         0.09865 M                              0.001349 M                0.001349 M**

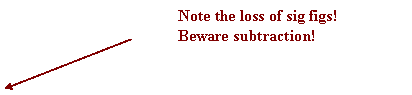
**Ka                   =          [H+][CH3COO-]**

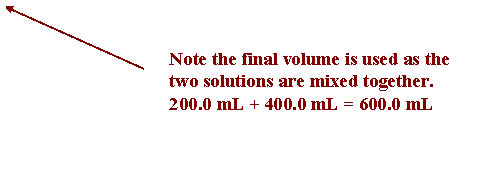
**[CH3COOH]**

**Ka                   =          (0.001349)( 0.001349)**

**(0.09865)**

**Ka       =          1.8   x   10-5**

* 13.       200.0 mL of 0.120 M H2SO4 reacts with 400.0 mL of  0.140 M NaOH. Calculate the pH of the resulting solution.
* **H2SO4                         +                      2NaOH                       ®        Na2SO4            +          2HOH**
* **0.200 L   x  0.120 mol  =  0.0240 mol                        0.400 L   x  0.140 mol  =  0.0560 mol**
* **L                                                                     L**
* 
* **I                       0.0240 mole                                        0.0560 mole**
* **C                     0.0240 mole                                        0.0480 mole**
* **E                     0                                                          0.0080 mole**

* **[OH-]              =          0.0080 mole    =          0.013 M**
* **0.6000 L**





* **pOH    =          1.88**
* **pH       =          12.12**

**WS # 12            Acid and Base pH Calculations**

For each weak bases calculate the [OH-], [H+], pOH and pH. Remember that you need to calculate Kb first.

1.   0.20 M CN-

**Kb(CN-)  =       Kw                 =          1.0  x  10-14     =          2.0408  x  10-5**



**Ka(HCN)**                    **4.9  x  10-10**

**CN-      +          H2O      D       HCN      +       OH-**

**I           0.20                                         0                      0**

**C         x                                              x                      x**

**E         0.20  -  x                                  x                      x**

**x2                     =                      2.0408  x  10-5**



**0.20  -  x**

**x  =  [OH-]  =  2.0 x 10-3M**

**[OH-] = 2.0 x 10-3M         pOH = 2.69     pH = 11.31      [H+] = 4.9 x 10-12 M**

2.   0.010 M NaHS (the basic ion is HS-)

**Kb = 1.1 x 10-7   [OH-] = 3.3 x 10-5M           pOH = 4.48     pH = 9.52        [H+] = 3.0 x 10-10M**

3.   0.067 M KCH3COO

**Kb = 5.55 x 10-10   [OH-] = 6.1 x 10-6M       pOH = 5.21     pH = 8.79        [H+] = 1.6 x 10-9M**

4.   0.40 M KHCO3

**Kb = 2.3 x 10-8   [OH-] = 9.6 x 10-5M           pOH = 4.02     pH = 9.98        [H+] = 1.0 x 10-10M**

5.  0.60 M NH3

**Kb = 1.786 x 10-5   [OH-] = 3.3 x 10-3M       pOH = 2.49     pH = 11.51      [H+] = 3.1 x 10-12M**

6.   If the pH of a 0.10 M weak acid HX is 3.683, calculate the Ka for the acid and identify the acid using your acid chart.

**H2X                  ⇄        H+                                HX-**

**I           0.100 M                      0                                  0**

**C         - 0.0002075                 0.0002075                   0.0002075**

**E         0.09979                       0.0002075                   0.0002075**

**Ka       =          (0.0002075)2               =          4.3   x   10-7                 Carbonic acid**

**(0.09979)**

7. Calculate the [H+], [OH-], pH, and pOH for 0.80 M H3BO3.

**[H+] = 2.4 x 10-5 M                [OH-] = 4.1 x 10-10 M                pH  =  4.62              pOH  =  9.38**

8. Calculate the [H+], [OH-], pH, and pOH for 0.25 M H2CO3.

**[H+] = 3.3 x 10-4  M                           [OH-] = 3.0  x 10-11  M              pH  =  3.48               pOH  =  10.52**

9. The pH of 1.65 M H3BO3 is 4.46. Calculate the Ka for H3BO3. Compare your calculated value with that in the table.

**Ka = 7.3 x 10-10[OH-] = 2.88 x 10-10MpH  =  4.46          [H+] =  3.47 x 10-5      pOH  =  9.54**

10. The pH of 0.65 M NaX is 12.46. Calculate the Kb for NaX.

**pOH  = 14.00  -  12.46  =  1.54                                        [OH-]  =  10-1.54  =  0.02884 M**

**X-      +          H2O      D       HX          +               OH-**

**I           0.65 M                        0                                  0**

**C         0.02884 M                              0.02884 M                  0.02884 M**

**E         0.6212 M                                0.02884 M                  0.02884 M**

**(0.02884)2**

**Kb  =**

**(0.6212)**

**Kb  =         1.3 x 10-3**

11. Consider the following reaction:  2HCl   +   Ba(OH)2  →   BaCl2    +    2H2O

When 3.16g samples of Ba(OH)2 were titrated to the equivalence point with an HCl solution, the following data was recorded.

Trial                Volume of HCl added

#1                    37.80 mL         **Reject**

#2                    35.49 mL

#3                    35.51 mL                                             Calculate the **original [HCl] = 1.04M**

**35.50 mL        Average**

**2HCl               +          Ba(OH)2  →   BaCl2    +    2H2O**

**0.03550 L                   3.16 g**

**3.16 g Ba(OH)2   x     1 mole     x      2 moles HCl**

**Molarity         =**

**171.3g             1  mole Ba(OH)2**



**0.03550 L**

**[HCl] = 1.04M**

12. Calculate the volume of 0.200M H2SO4 required to neutralize 25.0 ml of 0.100M NaOH.

**0.00625 L**

13. 25.0 ml of .200M HCl is mixed with 50.0 ml .100M NaOH, calculate the pH of the resulting solution.

**No excess pH = 7.000**

14. 10.0 ml of 0.200 M H2SO4 is mixed with 25.0 ml 0.200 M NaOH, calculate the pH of the resulting solution.

**pH = 12.456**

15. 125.0 ml of .200M HCl is mixed with 350.0 ml .100M NaOH, calculate the pH of the resulting solution.

**pH = 12.323**

16. Define standard solution and describe two ways to standardize a solution.

**A standard solution is one of known molarity. If you make the solution from a weighed amount of solid and dilute it to a final volume in a volumetric flask it is a standard solution. If you titrate a solution to determine its concentration it is a standard solution.**

17. What is the [H3O+] in a solution formed by adding 60.0 mL of water to 40.0 mL of 0.040 M KOH solution?

**[H+] = 6.3 x 10-13 M**

**WS # 13  Review**

1. List the properties of acids/bases.

**Acids- conduct electricity, taste sour, change the color of indicators, neutralize bases, react with active metals like Mg to produce H2 gas.**

**Bases- conduct electricity, taste bitter, change the color of indicators, neutralize acids, feel slippery.**

2. Define the following:

**Arhenius strong acid- completely ionizes to form H+**

**Arhenius weak base- partially ionizes to form OH-**

**Bronsted strong acid- completely donates a proton to a base**

**Bronsted weak base- partially accepts a proton to an acid**

**Conjugate pair – an acid base pair that differs by one proton**

**Amphiprotic- a chemical species that can be an acid or base**

**Standard solution- a solution of known molarity**

3.  Show by calculation if the following amphiprotic ions are acids or bases:

a)     HCO3-**Base                Ka = 5.6  x 10-11Kb = 2.3 x 10-8**

b)     H2PO4-**Acid                Ka = 6.2  x 10-8Kb = 1.3 x 10-12**

c)     HPO42-**Base****Ka = 2.2  x 10-13Kb = 1.6 x 10-7**

4. What is the strongest base in water?  What is the strongest acid in water? Write equations to explain your answer.

**Base    OH-                NaOH →   Na+    +     OH-**

**Acid    H+                   HCl     →        H+     +      Cl-**

5. Match each equation:

**Acid/base complete**               **HCl +  NaOH →NaCl + HOH**

**Acid/base net ionic**                **F- + HOH → HF + OH-**

**Solubility product**                   **H+ + OH- → HOH**

**Hydrolysis**                              **AgCl(s) → Ag+ + Cl-**

**Acid/Base formula**                 **H20 → H+ + OH-**

**Ionization of water**                **H+ + Cl-+ Na+  + OH-→Na++  Cl- + H2O**

6. **HCl** and **HF**.   Describe each acid as:

            a) **strong**/**weak**    b) **high**/**low** ionization   c) **large**or **small** Ka

            d) **good**/**poor** conductor  e) **strong** or **weak** electrolyte

7. **0.2M HCl** and **1.0M HF**.  Which is the **most concentrated**? Which is the **strongest acid**?

8.   Label the scale as strong/weak acid and strong/weak base.

            |\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_|\_\_

pH                   0                                              7                                                14

**SA              WA                                              WB                    SB**

9. Which ions are **amphiprotic**?

**HPO4-2**        HCl         F-         **HS-**          H2S           **H2O**

10. Write the net ionic equation between any acid and base.**H+ + OH- → HOH**

11. Write the ionization equation for water.**H20 → H+ + OH-**

12. Write the Kw expression.              **Kw = [H+][OH-] = 1.0  x 10-14**

13. H2SO3 + HS- <====> H2S + HSO3-

      a) Are the reactants or **products** favoured?

      b) Are the **Keq large**, small or about 1?

14. 0.20M HCl            **pH = 0.70**

15. 0.20M Ba(OH)2     **pH = 13.60**

16. 0.20M H2CO3        **pH = 3.53**

17. 0.40M KHCO3      **pH = 9.98**

18. The pH increases by 2 units.  How does [H+] change?     **Decreases by a factor of 100**

19. The pH decreases by 1 unit.    How does [H+] change?    **Increases by a factor of 10**

20.       a) For distilled water :            **pH = 7.00       pOH =7.00    [H+] = 1.0 x 10-7 M            [OH-] = 1.0 x 10-7 M**

b) For 1M HCl:                      **pH = 0.0          pOH =14.0    [H+] = 1 M                   [OH-] = 1.0 x 10-14 M**

c) For 1M NaOH         **pH = 14.0       pOH =0.0    [H+] = 1.0 x 10-14 M      [OH-] = 1 M**

21. The pH of .20M NaX is 12.50, calculate the Kb.

**Kb = 5.9 x 10-3**

22. The pH of .2M HX is 4.5, calculate the Ka.

**Ka = 5 x 10-9**

24. 100 mL of 0.200M NaOH and 100 mL of 0.100 M KOH is mixed with 100.0 mLof 0.100M HCl.

Calculate the pH of the resulting solution.

**pH = 12.52**

25. How many grams of NaHCO3 are required to make 100mL of .200M solution?

**1.68 g**

26. What volume of 0.200M NaOH is required to neutralize 25.0 mL of 0.150M H2SO4?

**0.0375 L**

27. In a titration 25.0mL of 0.200M H2SO4 is required to neutralize 10.0mL NaOH. Calculate the concentration of the base.

**1.00 M**

28. Calculate the concentration of a solution of NaCl made by dissolving 50.0g in 250 mL of water.

**3.42 M**

29.       2SO2(g) +          O2(g)                 ⇄        2SO3(g)

4.00 moles of SO2 and 5.00 moles O2 are placed in a 2.00 L container at 200ºC and allowed to reach equilibrium. If the equilibrium concentration of O2 is 2.00M, calculate the Keq.

**Keq = 0.500**

**Ws # 14 Buffers**

1. Definition (buffer)   **A solution that is made by mixing a weak acid or base with a salt containing the conjugate which maintains a relatively constant pH.**

2.

**Acid                                        Conjugate Base         Salt**

HCN                                        **CN-**                              **NaCN**

**H2CO3**                                               **HCO3-**                         KHCO3

NH4+                                       NH3                             **NH4Cl**

HF                                           **F-**                                 **NaF**

**CH3COOH**                            **CH3COO-**                   NaCH3COO

**H2C2O4                                   HC2O4-**                       Na HC2O4

3. Write an equation for the first three buffer systems above.

**HCN               ⇄        H+      +    CN-**

**H2CO3**                        **⇄        H+      +     HCO3-**

**NH3+          H2O⇄        NH4+   +    OH-**

4. Which buffer could have a **pH of 4.0 ?**       Which buffer could have a **pH of 10.0** ?

a)  HCl   &  NaCl         b)  **HF   &   NaF**       c)    **NH3    &   NH4Cl**

5. Predict how the buffer of pH = 9.00 will change. Your answers are 9.00, 8.98, 9.01, 2.00, and 13.00

                                                                                    Final pH

a) 2 drops of 0.10M HCl are added                            **8.98**

b) 1 drop of 0.10M NaOH is added                            **9.01**

c) 10 mL of 1.0 M HCl are added                               **2.00**

6. Write an equation for the carbonic acid, sodium hydrogencarbonate buffer system. A few drops of HCl are added. Describe the shift and each concentration change.

Equation:                     **H2CO3**                        **⇄        H+      +     HCO3-**

Shift     **left**           [H+] =         **increases**        [H2CO3] =       **increases**        [HCO3-] =             **decreases**

**Indicators**

1. Definition (Indicator)  **A weak acid whose conjugate base is a different color**.

2. Equilibrium equation                       **HInd  ⇄  H+     +      Ind-**

3. Colors for methyl orange     HInd    **red**      Ind-      **yellow**

4. Compare the relative sizes of [HInd] and [Ind-] at the following pH’s.

                                    Color                           Relationship

pH = 2.0                      red                               **[Hind] > [Ind-]**

pH = 3.7                      orange                         **[Hind] = [Ind-]**

pH = 5.0                      yellow                         **[Hind] < [Ind-]**

5. HCl is added to methyl orange, describe if each increases or decreases.

[H+]                             **increases**

[HInd]                         **increases**

[Ind-]                           **decreases**

Color Change              **yellow to red**

6. NaOH is added to methyl orange, describe if each increases or decreases.

[H+]                             **decreases**

[HInd]                         **decreases**

[Ind-]                           **increases**

Color Change              **red to yellow**

7. State two equations that are true at the transition point of an indicator.

**[Hind] = [Ind-]                        Ka = [H+]**

8. What indicator has a Ka = 4 x 10-8**Neutral Red**

9. What is the Ka for methyl orange.   **2 x 10-4**

10. A solution is pink in phenolphthalein and colorless in thymolphthalein. What is the pH of the solution?

**pH = 10**

11. A solution is blue in bromothymol blue, red in phenol red, and yellow in thymol blue. What is the pH of the solution?

**pH = 8**

**Ws # 15 Titration Curves**

Choose an indicator and describe the approximate pH of the equivalence point for each titration. Complete each reaction.

                                                                                                pH                   Indicator

1. HCl     +      NaOH  ------->                                                **7                      bromothymol blue**

2. HF     +        RbOH  ------->                                                **9                      phenolphthalein**

3. HI     +         Ba(OH)2  ------->                                            **7                      bromothymol blue**

4. HCN     +     KOH  ------>                                                   **9                      phenolphthalein**

5. HClO4     +  NH3  ------->                                                   **5                      bromocresol green**

6. CH3COOH     +       LiOH  ------->                                     **9                      phenolphthalein**

7. Calculate the Ka of bromothymol blue.**Ka = 2 x 10-7**

8. An indicator has a ka = 1 x 10-10, determine the indicator.  **Thymolphthalein**

9. Calculate the Ka of methyl orange.                                                  **Ka = 2 x 10-4**

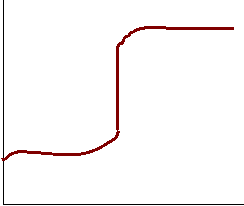
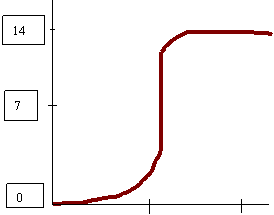
10. An indicator has a ka = 6.3 x 10-13, determine the indicator.   **Indigo Carmine**

11. Explain the difference between an equivalence point and a transition point.

**The equivalence point refers to endpoint of a titration (moles acid = moles base) and a transition point refers to when an indicator changes color.**

Draw a titration curve for each of the following.

12. Adding 100 ml 1.0 M NaOH to 50 mL 1.0 M HCl           13. Adding 100 ml 1.0 M NaOH to 50 mL 1.0 M HCN



pH

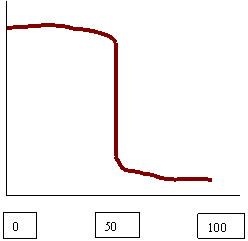
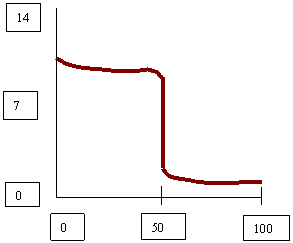






Volume of base added                                                             Volume of base added

14. Adding 100 ml 0.10 M HCl to 50 mL 0.10M NH3            15. Adding 100 ml .10 M HCl to 50 mL 0.10 M NaOH



pH                                                                   pH



Volume of base added                                                             Volume of base added

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