Chapter 18/19
Review Naming Acids and Bases.

ACIDS, BASES & SALTS

In the last chapter solutions were discussed. One of the solutions, electrolytes, can be divided in to three classes: acids, bases and salts. In this unit the relationship and properties of acids, bases and salts will be discussed. There are differing concepts for these substances, Arrhenius and Bronsted-Lowry.

Arrhenius Concept of Acids & Bases

In the Arrhenius concept an acid is a substance that, when dissolved in water, increases the concentration of hydrogen ion, H^+ (aq) and a base is a substance that, when dissolved in water, increases the concentration of **hydroxide ions, OH^-** (aq). The hydrogen ion is not found as a base H^+ but as **H_3O^+**, called a **hydronium ion**. A strong acid or base is one that completely ionizes in an aqueous solution.

For example: Strong acids: H_2SO_4, HI, HBr, HCl, & HNO_3
Strong bases: the hydroxides of groups IA & IIA.

Bronsted and Lowry Concept of Acids and Bases

In the Bronsted-Lowry concept an acid is a proton donor and a base is a proton acceptor. (We generally follow H^+ as the proton) When in solution there is an acid-base equilibrium. We refer to the components as conjugate acid-base pairs, one acid and one base that differ by the gain or loss of a proton. Amphoteric refers to a compound that can be either a proton donor or accepter depending on the other reactant, the most common is water.

For example: NH_3 (aq) + H_2O (l) → NH_4^+ (aq) + OH^- (aq)
(base) (acid) (acid) (base)

Thus NH_3 + NH_4^+ are conjugate pairs. When an acid looses an H^+ ion it becomes a conjugate base. NH_4 → NH_3 + H^+

Rules for the Bronsted Lowry Concept:

1. A base is the species that accepts the protons; the OH^- ion is only one example of a base.
2. Acids & Bases can be ions as well as other molecular substances.
3. Acid-Base reactions are not restricted to aqueous solutions.
4. Some species can act as either acids or bases, depending on what other reactant is.

Practice: Identify the following conjugate pairs.

1. HNO_3 (aq) + H_2O (*l*) → H_3O^+ (aq) + NO_3^- (aq)
   Pair 1: acid - _____ base - _____
   Pair 2: acid - _____ base - _____

2. HCN (aq) + H_2O (*l*) → H_3O^+ (aq) + CN^- (aq)
   Pair 1: acid - _____ base - _____
   Pair 2: acid - _____ base - _____

Self Ionization of Water

$H_2O\ (l)\ + H_2O\ (l) \rightarrow H_3O^+\ (aq)\ + OH^-\ (aq)$

Properties of Acids & Bases

1. **Taste**:Acids – sour or tart
   Bases – bitter
2. **Touch**: Weak acids feel like water, except on open skin – then it stings.
   Mild basic solutions feel smooth and slippery.
3. **Reactions with metals**: Acids react vigorously with many metals.
   Bases do not react with most metals.
4. **Electrical Conductivity**: Acids and bases are electrolytes and are good conductors of electricity.

Acids and bases can be identified in different ways, a pH meter or an indicator. A **pH meter** uses an electrode to measure H_3O^+ concentration and has a read out of the numerical value. **Indicators** are substances that turns one color when in presence of an acid and a different color when in the presence of a base. Indicators may be liquids or paper that has been impregnated with the indicator.

Ex: litmus paper
Acid – blue to red
Base - red to blue

Neutralization refers to when acids and bases are mixed together in the correct quantities they will "inactivate" or neutralize each other. The ionic compound that results from a neutralization reaction is a salt.

Properties of Salts

Salt Hydrolysis Reaction : when salts dissolve in water weak Bronsted-Lowry acids or bases.

To predict if a salt will produce an acid or a base:

1. Salts of strong acids + strong bases are neutral
2. Salts of strong acids + weak bases are slightly acidic.
3. Salts of weak acids + strong bases are slightly basic.
4. Salts of weak acids + weak bases can be acidic, basic, or neutral, it depends on the relative strength of the compounds.

Practice: Predict whether the final solution in each of the following will be acidic, basic, neutral or unpredictable.

1. $HCl\ (aq) + NH_3\ (aq)$ Result: _____
2. $HC_2H_3O_2\ (aq) + H_2O\ (aq)$ Result: _____
3. $H_3O^+(aq) + KOH\ (aq)$ Result: _____
4. $H_2SO_4\ (aq) + NaOH\ (aq)$ Result: _____

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Homework: Acids, Bases and Salts

Complete the following matching.

_____	1. Indicator	a.	A value that represents the concentration of hydronium ions.
_____	2. Amphoteric	b.	OH^-
_____	3. Conjugate pair	c.	Any substance that can act as an acid or base.
_____	4. Hydrolysis	d.	A compound formed by the combination of an acid and a base.
_____	5. Neutralization reaction	e.	When acids and bases are mixed together they will "inactivate" each other.
_____	6. Hydronium ion	f.	H_3O^+
_____	7. Dissociation	g.	A substance that changes color in the presence of an acid or base.
_____	8. Salt	h.	The acid and base that have exchagned a proton.
_____	9. Hydroxide ion	i.	The process in which an ion dissolves in a polar solvent.
_____	10. pH	j.	Reaction in which is used to break the reactant into two products.

Name the following acids and bases.

11. H_2SO_4 (aq) _____
12. NaOH (aq) _____
13. NH_3 (aq) _____
14. HCl (aq) _____
15. KOH (aq) _____
16. HNO_3 (aq) _____

Define the following.

17. Arrhenius acid and base.

18. Bronsted-Lowry acid and base.

Indentify the conjugate pairs for the following reactions.

19. $HCl\ (aq) + NH_3\ (aq) \rightarrow Cl^- + NH4^+$

Pair 1: acid - _____ base - _____

Pair 2: acid - _____ base - _____

20. $HC_2H_3O_2\ (aq) + H_2O\ (aq) \rightarrow C_2H_3O_2^- + H_3O^+$

Pair 1: acid - _____ base - _____

Pair 2: acid - _____ base - _____

21. $H_2SO_4\ (aq) + 2\ NaOH\ (aq) \rightarrow Na_2SO_4 + 2\ H_2O$

Pair 1: acid - _____ base - _____

Pair 2: acid - _____ base - _____

Predict the results of the following reactions. (acidic, basic, neutral or unable to determine.)

22. A strong acid reacts with a strong base. Result: _____

23. A strong base with a weak acid. Result: _____

24. A weak acid with a weak base. Result: _____

25. A weak base with a strong acid. Result: _____

QUANTITATIVE MEASUREMENT

When an reaction reaches equilibrium the result is a constant ratio between the concentrations of the compounds involved. This constant ratio is referred to as the equilibrium constant, K_{eq}.

For example: If given the equation $aA + bB \leftrightarrow cC + dD$

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

When using this constant for acid/base reactions we must consider that the concentration of H2O is essentially constant therefore the Ion-Product Constant for water is:

$K_w = [H_3O^+][OH^-] = 1.00 \times 10^{-14}$ @ 25° C

$= 2.5 \times 10^{-14}$ @ 37° C

The self ionization of water is: H_2O (l) + H_2O (l) → H_3O^+ (aq) + OH^- (aq) therefore, the concentration of $[H_3O^+]$ and $[OH^-]$ in pure water are both 1×10^{-7}.

$K_w = [H_3O^+][OH^-]$

$1.0 \times 10^{-14} = (1 \times 10^{-7})(1 \times 10^{-7})$

**you must know this!

We can also use this constant in conjunction with the concentration of either $[H_3O^+]$ or $[OH^-]$ to determine the missing piece.

- For example: Determine the OH^- concentration for a solution whose H_3O^+ concentration is 1.0×10^{-3} M at 25° C.

  $1.0 \times 10^{-14} = (1.0 \times 10^{-3})[OH^-]$

  $[OH^-] = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}}$

  $[OH^-] = 1.0 \times 10^{-11}$M

Practice: Determine the concentrations requested for the following problems.

1. Calculate the hydroxide ion concentration in a solution whose hydronium ion concentration is 1×10^{-5}M.

2. Calculate the hydronium concentration for a solution whose hydroxide concentration is 0.0010 M.

3. What is the hydroxide concentration of a solution if 0.080 grams of NaOH are dissolved in 2.0L of solution? What is the hydronium ion concentration of this solution?

pH of a Solution

To determine whether an aqueous solution is acidic, neutral, or basic, you need to calculate the hydronium – ion concentration (pH). pH is defined as the negative logarithm of the molar hydronium – ion concentration. (Be sure to be familiar with your calculator and how to enter this!) The amount of hydronium ions or hydroxide ions produced directly correspond to the molarity of the substance in solution. If HCl is in solution it produces one hydronium ion for every mole of HCl (also referred to as monoprotic), where H_2S in solution produces 2 hydronium ions for every mole. NaOH would produce one mole of hydroxide ions for every mole of NaOH in solution, $Ca(OH)_2$ would produce 2.

In an acidic solution $[H_3O^+] > 1.00 \times 10^{-7}$ M (pH < 7)
*a strong acid has a pH >2
Neutral solution $[H_3O^+] = 1.00 \times 10^{-7}$ M (pH = 7)
Basic solution $[H_3O^+] < 1.00 \times 10^{-7}$ M (pH > 7)

-For example: the $[H3O^+]$ for a solution is 1.0×10^{-3} M
The pH = 3.00

Practice: Complete the following.

1. What is the pH of a solution if the concentration of hydronium ions is 1.0×10^{-2}M? Is this solution acidic or basic?

2. What is the pH of a solution if the hydroxide ion concentration is 1.0×10^{-4}M? Is this solution acidic or basic?

3. What is the concentration of hydronium ions in a solution whose pH is 8?

4. For question number 3, what is the concentration of hydroxide ions?

5. What is the concentration of hydronium ion in a solution that has a volume of 2.50L and 5.33g of HCl? What is the pH of this solution.

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Homework: Quantitative Measurements for pH

Calculate the following concentrations. ✓ 1 H_3O^+/mole

1. Acetic acid is a weak monoprotic acid. It is the active ingredient in vinegar and the concentration of H_3O^+ is 0.0019M, calculate hydroxide concentration for acetic acid.

2. Ammonia is a weak base. The concentration of OH^- is 1.6×10^{-3} M, calculate the hydronium concentration for ammonia.

3. Formic acid is a weak monoprotic acid. The concentration of H_3O^+ is 4.2×10^{-3} M, calculate the hydroxide concentration for the formic acid.

4. Cyanic acid is a weak monoprotic acid. The concentration of H_3O^+ is 4.8×10^{-2} M, calculate the hydroxide ion concentration for cyanic acid.

5. Isobutylamine is a weak base. The concentration of OH^- is 4.0×10^{-3} M, calculate the hydronium concentration for isobutylamine.

6. Gallic acid is a weak monoprotic acid. The concentration of H_3O^+ is 3.3×10^{-3} M, calculate the hydroxide concentration for the gallic acid.

Complete the following questions.

7. In a solution of trimethylamine the concentration of OH^- is 4.4×10^{-3} M, calculate the pH. Is this acidic or basic?

8. In a solution of dipropylamine the concentration of OH^- is 0.012 M, calculate the pH. Is this acidic or basic?

9. A solution of uric acid has a concentration of H_3O^+ is 3.4×10^{-2} M, calculate the pH. What is the hydroxide concentration for this solution?

10. A butylamine solution contains an OH^- concentration of is 8.6×10^{-6} M, calculate the pH for butylamine.

11. Calculate the hydroxide ion concentration of pure water. What is its pH?

12. a. What is the concentration of hydronium ion in a 0.1 M solution of sodium hydroxide (NaOH)?
    b. What is the pH of this solution?

13. a. What is the concentration of hydronium ion in a solution whose pH equals 5?
    b. What is the concentration of hydroxide ion in this solution?

14. a. Calculate the concentration (molarity) of hydronium ion in a solution made by dissolving 1.90 g of hydrogen chloride (HCl) in enough water to make 0.642 L of solution.
    b. Calculate the pH and concentration of hydroxide ion in this solution.

15. a. Calculate the concentration of hydroxide ion in a solution made by dissolving 16.3 grams of potassiumhydroxide (KOH) in enough water to make 4.07 dm^3 of solution.
    b. Calculate the concentration of hydronium ion in this solution.
    c. Calculate the pH of this solution.

16. a. What is the concentration of hydronium ion in a solution that has a volume of 10.79 cm^3 and that contains 0.314 g of hydrogen sulfate (H_2SO_4)? Assume complete ionization of the solute.
    b. What is the concentration of hydroxide ion in this solution?
    c. What is the pH of this solution?

17. a. What is the concentration of hydroxide ion in a solution that has a volume of 3.55 dm^3 and that contains 0.00900 g of barium hydroxide ($Ba(OH)_2$)?
    b. What is the concentration of hydronium ion in this solution?
    c. What is the pH of this solution?

18. a. Calculate the concentration of hydronium ion in a solution whose pH is 5.17.
    b. Calculate the concentration of hydroxide ion in this solution.