Name:

Regents Chemistry:

Notes: Unit 10 Acids and Bases

Name:

KEY IDEAS

- Behavior of many acids and bases can be explained by the Arrhenius theory. Arrhenius acid and bases are electrolytes. (3.1uu)
- An electrolyte is a substance which, when dissolved in water, forms a solution capable of conducting an electric current. The ability of a solution to conduct an electric current depends on the concentration of ions. (3.1rr)
- Arrhenius acids yield H+ (aq), hydrogen ion as the only positive ion in an aqueous solution. The hydrogen ion may also be written as H_3O^+ (aq), hydronium ion. (3.1vv)
- Arrhenius bases yield OH- (aq), hydroxide ion as the only negative ion in an aqueous solution. (3.1ww)
- In the process of neutralization, an Arrhenius acid and an Arrhenius base react to form a salt and water. (3.1xx)
- Titration is a laboratory process in which a volume of solution of known concentration is used to determine the concentration of another solution. (3.1zz)
- There are alternate acid-base theories. One theory states that an acid is an H^+ donor and a base is an H^+ acceptor. (3.1yy)
- The acidity or alkalinity of a solution can be measured by its pH value. The relative level of acidity or alkalinity of a solution can be shown by using indicators. (3.1ss)
- On the pH scale, each decrease of one unit of pH represents a tenfold increase in hydronium ion concentration. (3.1tt)

PROCESS SKILLS

- Given properties, identify substances as Arrhenius acids or Arrhenius bases (3.1 xxxi)
- Identify solutions as acid, base, or neutral based upon the pH (3.1 xxxii)
- Interpret changes in acid-base indicator color (3.1 xxxiii)
- Write simple neutralization reactions when given the reactants (3.1 xxxiv)
- Calculate the concentration or volume of a solution, using titration data (3.1 xxxv)

Word	Definition
Acidity	The property of exhibiting the qualities of an acid.
Alkalinity	The property of exhibiting the qualities of a base
Arrhenius Acid	An electrolyte that ionizes in aqueous solution to yield H^+ as the only positive ion in solution.
Arrhenius Base	An electrolyte that ionizes in aqueous solution to yield OH^- as the only negative ion in solution.
Basicity	The property of exhibiting the qualities of a base
Bronsted/Lowry Acid (Alternate theory)	A species that donates H^+ to a B/L base in a chemical reaction.
Bronsted/Lowry Base (Alternate theory)	A species that accepts H^+ from a B/L acid in a chemical reaction.
Buret	A piece of laboratory equipment that precisely measures how much liquid has been let out of it by the valve on the bottom.
Caustic	A substance that will destroy or irreversibly damage any substance or surface it comes into contact with through a chemical change, usually used to describe bases.
Conjugate pair	An acid/base pair that differ only by one H^+. Acids turn into conjugate bases, bases turn into conjugate acids.
Corrosive	A substance that will destroy or irreversibly damage any substance or surface it comes into contact with through a chemical change, usually used to describe acids.
Dissociation	The separation of a molecule or salt into simpler molecules, atoms, radicals, or ions.
Electrolyte	A compound that ionizes in water, allowing the solution to conduct electricity.
Hydrolysis	The process whereby a base reacts with a glycerol ester (fat) to produce soap.

Vocabulary

Indicator	A substance whose color is sensitive to the pH of a solution to which it is added.
Neutralization	A double-replacement reaction where an acid and base react to form water and a salt.
Nonelectrolytes	A molecular compound that does not ionize in water, preventing the solution from conducting electricity.
pH	The negative log of the hydrogen ion concentration. A pH less than 7 indicates an acidic solution, a pH of greater than 7 indicates a basic solution and a pH of 7 indicates a neutral solution.
Protonation	The addition of an acid's H^+ ion (proton) to a water molecule to form hydronium (H_3O^+).
Salt	An ionic compound formed when an acid and base neutralize each other. This compound consists of the anion of the acid and the cation of the base.
Titration	A process of controlled acid-base neutralization, carried out using burets.

Lesson 1: Arrhenius Acids & Bases

Objective:

- Describe the meaning of Arrhenius acids and bases.
- Describe the properties of Arrhenius acids and bases

Svante Arrhenius, 1859-1927
Source: Wikipedia, 8 Mar 18

Arrhenius was studying the behavior of electrolytes and the ions produced which allowed for conductivity. He described acids and bases by the ions they produced in aqueous solutions.

ARRHENIUS ACID:
A substance that when dissolved in water increases the concentration **HYDROGEN IONS H^+**
(or HYDRONIUM ION H_3O^+)

EXAMPLE:
$HCl \rightarrow H^+ + Cl^-$
$HCl_{(g)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Acids ionize even though they are covalent. The oxygen in water is so negative, that it can pull the H+ away from the non-metal it is bonded to… Because they ionize, acids are electrolytes.

<u>Properties of Acids:</u>

- Sour Taste
- Can burn your skin
- React vigorously with metals to make $H_{2(g)}$
- pH is less than 7

EXAMPLE: $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

<u>Names of Common Acids and Formulas</u>

Located on **TABLE K** in reference table
The top 4 acids are all **<u>strong acids</u>** while the last 2 are **<u>weak acids</u>**.
All formulas can be written starting with "H"

ARRHENIUS BASE:
A substance when dissolved in water increases the concentration of **HYDROXIDE IONS OH^-**

EXAMPLE:

$NaOH_{(s)} \rightarrow Na^{+1}{}_{(aq)} + OH^{-1}{}_{(aq)}$

Properties of Bases

- Bitter taste
- Can be corrosive
- pH greater than 7

Names of Common Bases and Formulas

Located on **TABLE L** in reference table
All contain …OH → One Exception to Rule: **NH_3 (AMMONIA) is a base! In this case the Nitrogen in the ammonia pulls the H+ from the OH- in water, creating $NH_4OH(aq)$

The top 3 bases on table L are **strong bases** while the last 1 is a **weak base**.

BECAUSE ACIDS AND BASES IONIZE IN WATER, THEY ARE ELECTROLYTES.

Acid and Base Strength:

- Strong acids and bases are completely dissociated in water to make a lot of H^+ or OH^-.
- Weak acids and bases only dissociate partially in water to make a small amount of H^+ or OH^-

How is strength different from concentration?
STRENGTH refers to the amount of ions a substance makes when it breaks down.
CONCENTRATION refers to the amount of the substance initially, before it breaks down. This is usually measured in molarity (mol/L).

EXAMPLE: Which substance can be classified as an Arrhenius acid?
HCl
NaCl
LiOH
KOH

Lesson 2: Alternate Acid/Base Theory

Objective:

- ***Differentiate between a Acid and Base using the alternate theory (Bronsted Lowry)***
- ***Identify conjugate acids and bases***

Johannes Nicolaus Brønsted and Thomas Martin Lowry, in 1923, categorized acids and bases by how they reacted, i.e., in terms of proton (H+) transfer

BRONSTED LOWRY THEORY: BAAD (Bases ACCEPT, Acid DONATE – H+, that is)
Acid- proton (H^+) DONOR
Base- proton (H^+) ACCEPTOR
(Protons refer to hydrogen ions)

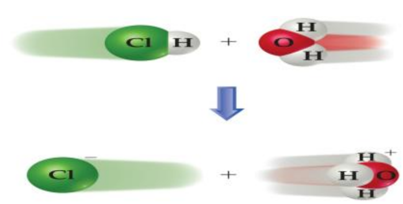
EXAMPLE: Identify the acid and base (always a reactant)
NH_3 + HOH → NH_4^+ + OH^-

EXAMPLE: Identify the acid and base
HSO_4^- + H_2O → H_3O^+ + SO_4^{-2}

EXAMPLE: Identify the acid and base
HI + H_2O → I^- + H_3O^+

What occurs when an acid dissolves in water?

Water acts as a Brønsted–Lowry base and removes a proton (H^+) from the acid.

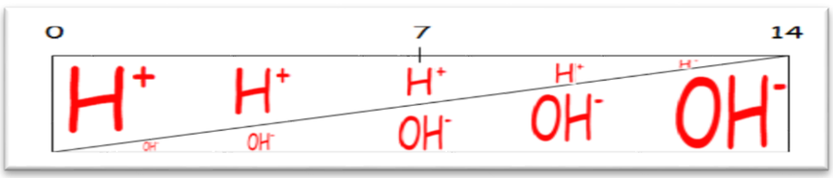


As a result, the hydronium ion are formed.

Objective:
- ***Differentiate between an Acid and Base on the pH scale***
- ***Determine the change in H+ or OH- concentration during a change in pH***

pH SCALE:
Direct measurement of **H^+ (H_3O^+) ION CONCENTRATION** in a solution
Measures HOW ACIDIC or HOW BASIC an aqueous solution is.

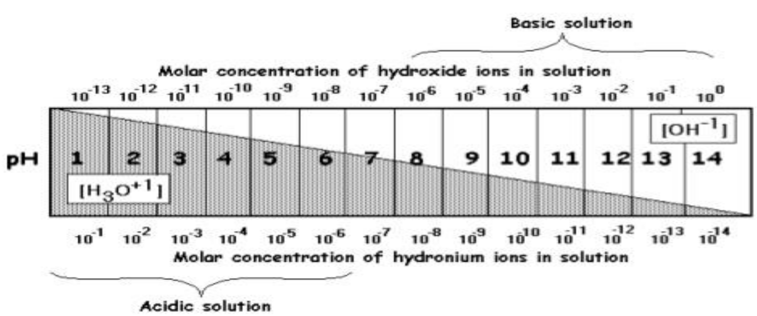
The pH scale ranges from 0 TO 14 (ACIDIC → neutral → BASIC)



<u>The ratio of $[H^+]$ to $[OH^-]$ determines pH</u>
- In acids $[H^+] > [OH^-]$
- In bases $[H^+] < [OH^-]$
- When neutral $[H^+] = [OH^-]$

<u>CHANGING pH</u>

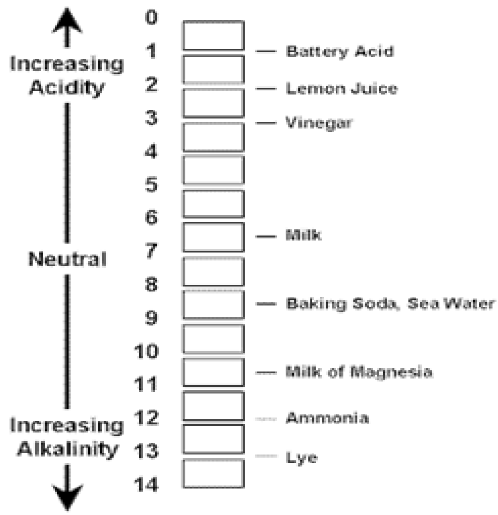
Each change of a SINGLE pH UNIT signifies A TENFOLD CHANGE IN $[H^+]$ CONCENTRATION



EXAMPLE:
A solution with a pH of 3 is 100 times more acidic than a solution with a pH of 5.

EXAMPLE:
A pH of 4 is how many times more acidic than a pH of 6?

pH of Common Acids and Bases



EXAMPLE:
Adding 0.1 M NaOH to a 0.1 M solution of HCl will cause the pH of the solution to?
Decrease
Increase
Remain the same

Acid-Base Indicators (Table M):
INDICATOR: Substance that **CHANGES COLOR** as a result of a **pH CHANGE**
Used to determine if a solution is acidic or basic, or to narrow down the range of pH of a solution.

Using Table M
If pH is **LOWER** than left hand number it will be the color on the **LEFT**.
If pH is **HIGHER** than right hand number it will be the color on the **RIGHT**.
If pH is approximate range it will be a **BLEND OF BOTH COLORS**.

EXAMPLE:
Methyl orange is RED from a pH of 3.2 or lower, and YELLOW from a pH of 4.4 or more. The middle of the range (3.2 - 4.4) is an intermediate (blended) color (in this case, ORANGE).

Using Multiple Indicators to Narrow down the pH range
EXAMPLE:
A solution turns **blue** with bromcresol green (>5.4) and **yellow** with bromthymol blue (<6.0)
The pH range is between 5.4-6.0.

Lesson 4: Neutralization Reactions and Titration

Objective:

- ***Describe a neutralization reaction***
- ***Calculate the concentration of an unknown acid or base using the titration formula***

NEUTRALIATION: When an acid and a base react to form WATER and a SALT(neutral solution)

What occurs when an acid is added to a base?

The result is a **NEUTRALIZATION** when all properties of the acid and base are lost.

- The products are a salt and water

Example: $NaOH + HCl \rightarrow H_2O + NaCl$

***A salt is another name for solid ionic compounds containing elements other than H^+ and OH^-. Salts are electrolytes with high mp and bp

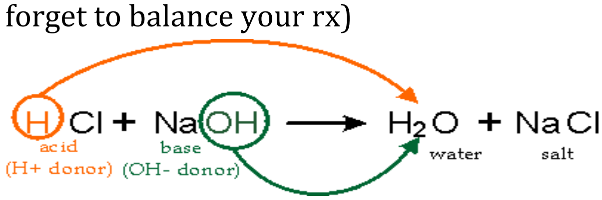
EXAMPLE: Label and Name the acid, base and salt

1. $H_2SO_4 + LiOH \rightarrow H_2O + Li_2SO_4$

2. $KOH + HNO_3 \rightarrow KNO_3 + H_2O$

Completing a Neutralization Reaction

H^+ and OH^- combine to make water and the left over metal & nonmetal combine to make a salt (don't forget to balance your rx)



EXAMPLE: Complete the neutralization reaction

$HBr_{(aq)} + KOH_{(aq)} \rightarrow$

EXAMPLE: Complete the neutralization reaction

$HNO_{3(aq)} + Ca(OH)_{2(aq)} \rightarrow$

(Acid-Base) Titration:

The controlled process of acid-base neutralization.

Used to determine the **unknown concentration** of an acid or base.

ENDPOINT- The pH at which an indicator that has been added to a titration setup turns color.

Solving Titration Problems

Use Titration Formula from Table T

MaVa =MbVb

EXAMPLE:

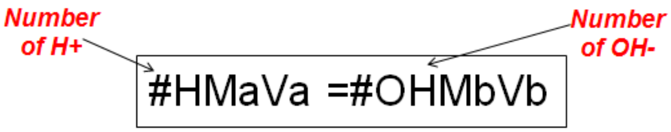
What is the concentration of a solution of HI if 0.3 L is neutralized by 0.6 L of 0.2M solution of KOH?

EXAMPLE: What is the molarity of NaOH if 100.mL of 3.00M HCl is titrated with 200.mL of NaOH?

********EXCEPTION…………**

The titration formula only works if the acid and the base have equal numbers of H^+ and OH^-.

If not, the acid side must be multiplied by the number of hydrogen ions and the base side must be multiplied by the number of hydroxide ions in the formulas



EXAMPLE:

You have 50 mL of 1.0 M $H_2SO_{4(aq)}$. What volume of 0.5 M NaOH would be required to neutralize the acid?

Remember → Diprotic Acids yield 2 H^+ ions in solution so multiply by 2!

EXAMPLE:

What is the molarity of a solution of $Ca(OH)_2$ if 750mL of it is titrated with 250mL of 3.5M H_3PO_4?