Name:_____
Blk:____Date:_____

ACID-BASE PACKAGE
Chemistry 11
Assignment # 5

Due:_____
Read pgs 370-379 and the following photocopied pages before answering the following questions:

Acids (Arrhenius's Definition)

According to Arrhenius, an **acid** is a substance that yields hydrogen ions (H^+) as the only positive ions when it is mixed with water. By this definition, the gas hydrogen chloride is an acid. See Figure 19-5.

IONIZATION OF HYDROGEN CHLORIDE GAS

$$HCl(g) \rightarrow H^+(aq) + Cl^-(aq) \qquad \text{(Eq. 3)}$$

hydrogen chloride gas → hydrogen ion + chloride ion = hydrochloric acid

This equation tells you that when hydrogen chloride gas is passed into water, it reacts to form hydrogen ions (as the only positive ion) and chloride ions. In a closed container, an equilibrium exists. However, the concentration of the hydrogen chloride molecules is so low and the concentrations of the ions so high that a single arrow pointing to the right is usually used in the equation. For all intents and purposes, the equilibrium mixture consists almost entirely of ions.

The large concentration of ions makes water solutions of hydrogen chloride gas very good conductors of electricity. In other words, hydrogen chloride gas is a strong electrolyte.

Experiments done since the time of Arrhenius have shown that, in water solutions, hydrogen ions (protons) always have water molecules attached to them. That is, hydrogen ions in aqueous solutions are always hydrated. The hydration of the hydrogen ion can be shown by the following equation:

$$H^+ + H_2O \rightarrow H_3O^+ \qquad \text{(Eq. 4)}$$

hydrogen ion → hydronium ion

Physical evidence suggests that in some dilute acid solutions, more than one molecule of water might be attached to the hydrogen ions. However, when writing the hydrogen ion in equations, the usual practice is to represent it by the symbol $H^+(aq)$ or to show it hydrated by a single water molecule: H_3O^+. Using the hydronium ion, H_3O^+, the ionization of hydrogen chloride would be shown by the following equation. Figure 19-6 shows the reaction with a model that uses circles to represent atoms.

IONIZATION OF HYDROGEN CHLORIDE GAS

$$HCl(g) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq) \qquad \text{(Eq. 5)}$$

hydrogen chloride gas

Compare Equation 5 with Equation 3 at the beginning of this section. For simplicity, the ionization equations of hydrogen chloride and other acids often are written to show the formation of the hydrogen ion (H^+) rather than the hydronium ion (H_3O^+). In the simpler equation (Eq. 3), water does not appear as a reactant.

The table in Figure 19-7 lists some common acids.

Figure 19-5
The solution formed when HCl gas dissolves in water is called hydrochloric acid. HCl is extremely soluble in water.

CAUTION: *Concentrated acids are corrosive and can cause severe burns. The heat generated when concentrated acids, especially H_2SO_4, are mixed with water can cause the acid to splatter. When diluting an acid, the proper procedure is to slowly add the acid to the water, never the water to the acid.*

Properties of Acids

1. ***Acids are molecular substances that ionize when added to water.*** The greater the degree of ionization of an acid, the better its water solution will conduct a current. You already have learned that hydrochloric, sulfuric, and nitric acids ionize almost completely and thus are strong acids. Acetic acid and hydrosulfuric acid ionize only slightly and thus are weak acids.

2. ***Acids react with metals that are chemically active to produce hydrogen gas.*** Sodium, magnesium, aluminum, and zinc are examples of active metals. Gold, platinum, silver, and copper are examples of inactive metals, that is, metals that do not react with aqueous solutions of acids. A typical equation for the reaction between an active metal and a water solution of an acid is:

MOLECULAR EQUATION

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g) \qquad \text{(Eq. 9)}$$

dilute hydrochloric acid

This equation says that zinc metal reacts with dilute hydrochloric acid to produce dissolved zinc chloride and hydrogen gas. The zinc chloride remains in solution as zinc ions and chloride ions while the hydrogen gas bubbles away. See Figure 19-10.

Recall from Section 19-4, Equation 5, that dilute hydrochloric acid consists of hydrated hydrogen ions and chloride ions. It is the hydrogen ions and the zinc metal that are the active ingredients in the reaction between zinc and dilute hydrochloric acid. The chloride ions from the acid are called *spectator ions.* (See Section 9-13 for a discussion of reactions in which spectator ions are present.) You therefore can use another way, known as an *ionic equation,* of

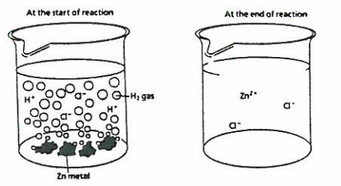

Figure 19-10
The reaction of zinc metal with dilute HCl. At the start of the reaction, the solution contains H^+ and Cl^- ions. At the end of the reaction, it contains Zn^{2+} and Cl^- ions. The H^+ ions form hydrogen gas that bubbles away. (If excess zinc metal is present at the start, some will be left over at the end of the reaction. If there is excess HCl, some H^+ ions will be left over.)

conveying the same information shown in Equation 9:

IONIC EQUATION

$$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

OR

$$Zn(s) + 2H_3O^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g) + 2H_2O(l) \text{ (Eq. 10)}$$

Dilute sulfuric and nitric acids (but *not* the concentrated acids) also contain large concentrations of hydrated protons. Therefore, the reaction of these *dilute* acids with zinc metal yields the same products, namely aqueous zinc ions and hydrogen gas.

3. ***Acids affect the colors of acid-base indicators.*** **Indicators** are substances that have one color in an acid solution and another color in a basic solution. (Bases will be discussed shortly.)

4. ***Acids neutralize bases.*** Neutralization reactions will be discussed in Section 19-7.

5. ***Dilute acids have a sour taste.*** Citrus fruits, vinegar, and sour milk taste sour because of the presence of dilute acids. Some acids, such as oxalic acid, are poisonous.

Arrhenius Bases and Their Properties

According to the definition of Arrhenius, a base is a substance whose water solution yields hydroxide ions (OH^-) as the only negative ions. By this definition, sodium hydroxide, NaOH, and ammonia, NH_3, are both examples of bases.

The following properties are typical of bases.

1. *Bases are electrolytes.* The aqueous solutions of bases conduct an electric current. Bases such as NaOH and KOH exist as ions in their solid phase. They dissolve readily in water to produce solutions containing large concentrations of ions.

DISSOCIATION EQUATION FOR NaOH

$$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq) \qquad \text{(Eq. 11)}$$

Weak bases such as ammonium hydroxide are molecular substances that ionize only slightly in water and are thus poor conductors.

Some Neutralization Reactions

H_2SO_4 dilute sulfuric acid	+	2NaOH sodium hydroxide	→	$2H_2O$ water	+	Na_2SO_4 sodium sulfate
$HC_2H_3O_2$ dilute acetic acid	+	NaOH sodium hydroxide	→	H_2O water	+	$NaC_2H_3O_2$ sodium acetate
HNO_3 dilute nitric acid	+	KOH potassium hydroxide	→	H_2O water	+	KNO_3 potassium nitrate
HCl dilute hydrochloric acid	+	KOH potassium hydroxide	→	H_2O water	+	KCl potassium chloride

gure 19-13
Some neutralization reactions. Solutions of the bases sodium hydroxide and potassium hydroxide will neutralize dilute solutions of the acids shown. In every reaction, one of the products of the reaction is water. The other product is a salt formed from the anion of the acid and the cation of the base.

IONIZATION EQUATION FOR AMMONIA GAS, NH_3

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^- \qquad \text{(Eq. 12)}$$

2. *Bases cause indicators to turn a characteristic color.* See again Figure 19-11.

3. *Bases neutralize acids.* Concentrated solutions of bases and concentrated solutions of acids are both very corrosive. Both cause severe burns when in contact with the skin. Yet when solutions of NaOH and HCl are mixed with each other in the right proportion, a solution of salt in water is produced.

$$NaOH(aq) + HCl(aq) \rightarrow \underbrace{NaCl(aq) + H_2O(l)}_{\text{salt water}} \qquad \text{(Eq. 13)}$$

The mutual destruction of a base and acid when solutions of the two are mixed is called *neutralization*. To be more precise, **neutralization** is a chemical reaction between an acid and a base to produce a salt and water. In common usage, the word *salt* is usually taken to mean *table salt*, which is sodium chloride, NaCl. However, table salt is only one salt among many. Figure 19-13 gives some other neutralization reactions.

* NOW READ Pgs 370-379 in Chemistry 11 text. *.

PART ONE: INTRO TO ACID-BASE CHEMISTRY

1. Compare and contrast the characteristic properties of Acids & Bases from Table 19.2 pg 372

2. Explain how litmus paper reacts in the presence of an acid or a base.

3. Solutions with a high $[H^+]$ are considered _____, an example is _____. Solutions with low $[H^+]$ are considered _____, an example is _____.

4. One of the earliest definitions of an acid was proposed by Svente Arrhenius, according to Arrhenius, an acid is

5. Here is an example of an acid-base reaction:

$$HCl\ (l) + H_2O\ (l) \dashrightarrow H_3O^+(aq) + Cl^-(aq)$$

Because H_3O^+ represents a HYDRATED PROTON (H^+) the notations H_3O^+ and H^+ are _____!

$$\boxed{H_3O^+ = H^+}$$

6. The ionization of water is written $H_2O \rightarrow H^+ + OH^-$. Is water an acidic or basic solution? What test could you perform to gain evidence to support your hypothesis? Explain.

7. Using the Arrhenius definition of a base, explain why sodium hydroxide is a base in solution, write the chemical formula.

8. Define a Bronsted-Lowry acid and base, give an example of each.

9. Define the term AMPHIPROTIC, and give an example of an amphiprotic compound.

10. Explain how NEUTRALIZATION occurs between an acid and a base.

11. Write the equation to represent the formation of **IONS** for the following STRONG acids and bases in water, indicate whether the compound is an acid or a base.

example: $HClO_4 \rightarrow H^+(aq) + ClO_4^-(aq)$

$HCl \rightarrow$
$HBr \rightarrow$
$HI \rightarrow$
$HNO_3 \rightarrow$
$LiOH \rightarrow$
$NaOH \rightarrow$
$KOH \rightarrow$
$RbOH \rightarrow$
$Ca(OH)_2 \rightarrow$
$Ba(OH)_2 \rightarrow$

PART II: ACID- BASE TITRATIONS

Read pgs 394-405 and then answer the following questions:

1. When an acid, such as HCl, and a base, such as KOH combine, they react with each other to produce _____.
   Write the chemical equation here:

2. When **moles** of protons DONATED by the acid and **moles** of protons ACCEPTED by the base are equal _____ occurs.

3. Define a "**SALT**":

Do section Review pg 404 #'s 1, 2, 4+5