Acids, Bases and Salts

Acids

Acids are compounds that are found in fruits and vegetables. Some insects use acids as a form of defense. Acids are also found in your digestive system. Acids are known by their sour taste. ***DO NOT EVER TASTE AN ACID IN THE LAB!!!!*** Acids will also turn litmus red (this is the only test for acid you should use in the lab).

In the 1800's Svante Arrhenius proposed the first molecular theory of acids. He proposed that acids are compounds that produce hydrogen ions in aqueous solution. This is a rather narrow definition of acids and was later expanded; however, we will use this definition.

Acids can be classified as strong or weak. A strong acid is one that dissociates completely in aqueous solution. The strong acids are HI, HBr, HCl, HNO_3, $HClO_3$, $HClO_4$, and H_2SO_4. Any acid not listed in this list is weak. A weak acid is one that does not dissociate completely in solution.

Acids will react with metals. When this reaction occurs the metal is converted into an aqueous metal ion and the hydrogen ions from the acid are converted into hydrogen gas. An example of this reaction is:

$$Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

Here the metal is "dissolved" in the form of the aqueous magnesium chloride. Acids will also react with bases.

Another reaction of acids that you need to know is the reaction between an acid and a carbonate (CO_3^{2-}) or bicarbonate (HCO_3^{-}). One of the products of this reaction is carbon dioxide. Examples of these reactions are:

$$2\ HBr_{(aq)} + Na_2CO_{3\,(aq)} \rightarrow 2\ NaBr_{(aq)} + H_2O_{(l)} + CO_{2\,(g)}$$
$$HBr_{(aq)} + NaHCO_{3\,(aq)} \rightarrow NaBr_{(aq)} + H_2O_{(l)} + CO_{2\,(g)}$$

Acids can be classified by the number of acidic hydrogens they have. For example, hydrochloric acid has one hydrogen and it is acidic. However, acetic acid has four hydrogens, but only one of them is acidic. This is usually denoted when writing the chemical formula by writing all of the acidic hydrogens at the beginning of the formula. Any non-acidic hydrogens are written within the formula. Therefore, the formula

$HC_2H_3O_2$ for acetic acid shows that there is one acidic hydrogen (written in front) and three non-acidic hydrogens, written within the rest of the formula.

Bases

Bases are compounds that, when dissolved in water, have a slippery or soapy feel. Bases have a bitter taste to them (again do not ever taste a base in the lab). Litmus will turn blue in the presence of bases.

Arrhenius defined bases as compounds that will produce hydroxide ion (OH^-) in solution. Bases can also be classified as strong or weak. The strong bases are LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Ba(OH)_2$, and $Sr(OH)_2$. All bases similar to ammonia (NH_3) are weak bases.

The only reaction that we will look at of bases is their neutralization reaction with acids. In these reactions the acid reacts with the base to produce a salt and sometimes water.

Salts

Salts are compounds that are the main product of the reaction between acids and bases. Table salt, NaCl, is only one of a class of thousands of compounds known as salts. Salts do not necessarily have a salty taste. The taste of table salt is due to the presence of the chloride ion. Anions that are not chemically similar to chloride will not provoke the taste sensation known as salty.

Salts can react with acids, bases, or other salts.

Ionic equations

Sometimes we wish to use a chemical equation that shows only what is happening in the chemical reaction. Any other extraneous information is not needed. We can show this by using ionic equations. An ionic equation differs from a chemical (or molecular) equation in that everything that exists primarily as ions in the solution is written as ions. Everything that is a solid, liquid, or gas, is written as a compound. In order to write an ionic equation we need to recall the solubility rules from the previous chapter:

Solubility Rules

1. All ionic compounds of Group IA metals, ammonium, acetate, and nitrate are soluble.
2. All halide compounds (Cl^-, Br^-, I^-) are soluble unless combined with Ag^+, Pb^{2+}, Hg_2^{2+}.

3. Most sulfate compounds are soluble except when combined with Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^{+}, Pb^{2+}, Hg_2^{2+}.
4. Most carbonates, phosphates, and sulfides are INSOLUBLE, except Rule 1.
5. Most hydroxides are insoluble except Group IA, Ca^{2+}, Sr^{2+}, Ba^{2+}.

We also need to remember which acids and bases are strong or weak. Anything that is a weak acid or base will be written in molecular form. Any strong acids or bases will be written in ionic form. All soluble ionic compounds will be written in ionic form. All insoluble ionic compounds will be written in molecular form. For example, we have sodium sulfate reacting with calcium nitrate. First we complete the double replacement reaction and balance it.

$$Na_2SO_4 + Ca(NO_3)_2 \rightarrow CaSO_4 + 2\ NaNO_3$$

Then we decide based on the rules above, what is soluble and what is not.

$$Na_2SO_{4\,(aq)} + Ca(NO_3)_{2\,(aq)} \rightarrow CaSO_{4\,(s)} + 2\ NaNO_{3\,(aq)}$$

Now we write all soluble ionic species, strong acids and bases as separated ions. Anything else will be written as compounds.

$$2\ Na^{+}_{(aq)} + SO_4^{2-}{}_{(aq)} + Ca^{2+}_{(aq)} + 2\ NO_3^{-}{}_{(aq)} \rightarrow CaSO_{4\,(s)} + 2\ Na^{+}_{(aq)} + 2\ NO_3^{-}{}_{(aq)}$$

This gives us the total ionic equation. We may notice, especially in this example, that there are ions that appear on both sides of the equation in the same form. These are called spectator ions. Spectator ions can be cancelled out of the equation to give the net ionic equation.

$$SO_4^{2-}{}_{(aq)} + Ca^{2+}_{(aq)} \rightarrow CaSO_{4\,(s)}$$

The net ionic equation shows exactly what is happening in the reaction. For instance here, the calcium ion is reacting with the sulfate ion to produce the solid calcium sulfate.