

CHEM 130

Conductivity

Background:

This experiment is designed to show the differences between ionic and covalent compounds and the nature of the bonding forces within them. Since conductivity is the flow of mobile charge carriers (such as electrons in wires or ions in water), then measuring the conductivity of species dissolved in water will allow the determination of how they actually exist in solution.

Ionic compounds consist of a 3D lattice of alternating cations (positively charged) and anions (negatively charged). The electrostatic attraction between opposite charges is very strong and gives ionic solids certain physical characteristics to be discovered in this lab.

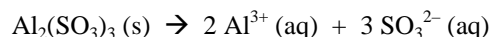
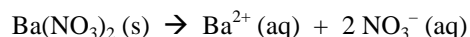
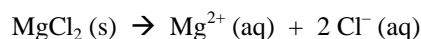
Covalent compounds consist of molecules with strong intramolecular bonds between atoms due to shared electrons, but the forces of attraction between these molecules (intermolecular forces) are much weaker than those in ionic solids. This affects the melting and boiling points as compared to ionic compounds (usually much lower).

Ionic and covalent compounds also act differently when dissolved in water due to the different bonding forces within them. When a **solute** (substance being dissolved) is dispersed within a **solvent** (substance doing the dissolving), such as water, the ions within an ionic compound are separated, whereas the molecules of covalent compounds remain intact. The homogeneous mixture formed is called a **solution**. Any compounds that form ions when dissolved in water are considered to be **electrolytes**. The more ions formed, the stronger the electrolyte, and the greater the current it will conduct. If no ions are formed when dissolved, it is called a non-electrolyte.

Representation of Species in Solution:

Ionic Compounds:

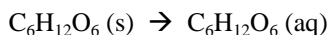
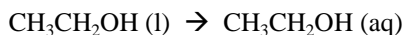
When a solid ionic compound dissolves in water, the ions become separated, and are written as dissociation reactions. Note that the equation must remain balanced, with the same number of each type of ion on either side of the arrow. Also, the charges of ions must always be included when written alone in solution, but never when part of an ionic compound. Several examples are shown below, with (aq) representing a species dissolved in water. Since ions are formed in each case, they would all conduct a current.



So, for example, the proper representation of MgCl_2 in solution would be as $\text{Mg}^{2+} (\text{aq}) + 2 \text{Cl}^{-} (\text{aq})$.

Covalent Compounds:

Other than acids and bases (discussed later), the covalent compounds in this class that dissolve in water do so without breaking any covalent bonds. These molecular species dissolve without forming any ions, and therefore will not conduct a current and are considered nonelectrolytes. Some examples of these species dissolving in water are shown below.

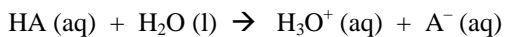


The proper representation of nonelectrolytes in solution are as their original molecular formulas in aqueous states.

Acids:

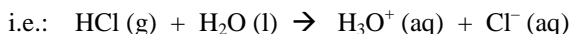
Acids are different from ionic or normal covalent compounds in that they *react* with water when they are dissolved by donating a hydrogen ion (H^+) to water. The new species formed are the **hydronium ion (H_3O^+)** and the anion from that particular acid.

A general reaction for an acid, HA, is as follows, and is called an Ionization reaction:



The extent to which the acid reacts with water determines whether it is a Strong or a Weak acid.

I: Strong Acids: In dilute solution, the reaction with excess water is complete (100 %).



Thus, if one of the reagents you use is any one of the following strong acids, the proper representation in solution is as the hydronium ions and anions, since these species dominate. The strong acids we will consider in are:

HCl (as H_3O^+ and Cl^-)

HBr (as H_3O^+ and Br^-)

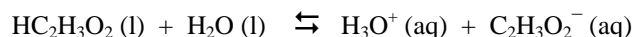
HI (as H_3O^+ and I^-)

HNO_3 (as H_3O^+ and NO_3^-)

H_2SO_4 (as H_3O^+ and HSO_4^-).

HClO_4 (H_3O^+ and ClO_4^-)

II: Weak Acids: These acids only react with water to a small extent (usually less than 10% completion), and so the dominant species in solution would be the original weak acid, and would be written this way in equations. The ionization reactions are written with reversible arrows to show that there is an equilibrium between all species in solution. An example is acetic acid, shown below:



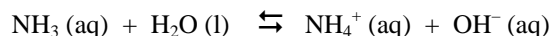
Note: acetic acid is sometimes written as $\text{CH}_3\text{CO}_2\text{H}$ or CH_3COOH , with the acidic hydrogen isolated on the far right.

Bases:

Bases are treated like acids in that there are both weak and strong bases, depending on the degree to which they react with water. For bases, the species formed is the hydroxide ion, OH^- .

Strong bases ionize to 100% extent (are strong electrolytes) and are represented as the products formed. Strong bases are the alkali metal hydroxides (NaOH , KOH , etc.) and some of the alkaline earth metal hydroxides like Ca(OH)_2 .

Weak bases are weak electrolytes and, like weak acids, are represented as their original formulas in solution. Bases react opposite to acids in that they accept a hydrogen ion from water. An example is ammonia:



So ammonia would be written as NH_3 (aq) when used in writing equations in solution.

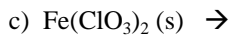
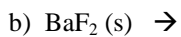
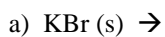
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CHEM 130

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Conductivity Prelab

1) Write dissociation reactions for the following soluble ionic compounds:



2) Given the conductivity information for the following species, write the equations for each dissolving in water, as well as the most proper representation of it in solution:

a) HNO_3 dissolved in water is a strong conductor:

b) HNO_2 dissolved in water is a weak conductor:

c) Sucrose (table sugar), $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, does not conduct any current:

d) Methylamine, CH_3NH_2 , is a weak conductor and a base:

e) HBr dissolved in water is a strong conductor:

f) Na_2CO_3 is a strong conductor: