CMN-100 Conductivity Meter

Overview

Conductivity is the ability of a substance to conduct an electric current. The principle by which conductivity is measured is fairly easy - two electrodes are placed in the solution, a potential is applied across the electrodes, and the current is measured. Conductivity (G) is the inverse of resistivity (R). This can be determined from the voltage and current values according to Ohm's law:

$$G = I/R = I \text{ (amps)} / E \text{ (volts)}$$

Since the ions in a solution facilitate the conductance of an electrical current, the conductivity of a solution is proportional to its ion concentration. Conductivity is generally measured in microsiemens (uS). Microsiemens are the modern units of the inverse of resistivity or mho.

In some situations, however, conductivity may not correlate directly to concentration. The graphs below illustrate the relationship between conductivity and ion concentration for two common solutions. Notice that the graph is linear for the sodium chloride solution, but not for a highly concentrated sulfuric acid solution. Ionic interactions can alter the linear relationship between conductivity and concentration in some highly concentrated solutions.

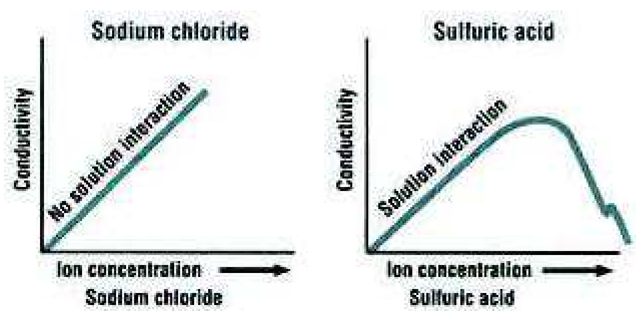

Figure GB-6-B1: Graphs showing the concentration vs. conductivity of two different solutions.

Ions that move through solution easily are better conductors. Small, fast moving ions like hydrogen (H^+) have a greater conductivity than do larger ions like bromide ion (Br^-), or heavily hydrated ions like the sulfate ion (SO_4^{2-}).

Conductivity is a useful method for measuring how good a conductor a substance will be. Conductive substances are usually referred to as electrolytes. Thus, electrolytes are compounds that dissolve in water and dissociate into ions. In solutions of electrolytes, several different substances may be present, including complete, whole molecules and dissociated ions.

Strong electrolytes dissociate completely into ions. A 1.0 M solution of the strong ionic electrolyte "AB" contains 1.0 M "A^+" ions, 1.0 M "B^-" ions, and 0.0 M "AB" molecules. In other words, the ions are the only substances present in a solution of a strong electrolyte. Diluting a 1.0 M solution of "AB" with water to 0.50 M reduces the concentration of ions by one half, which also reduces the conductivity of the solution by one half.

Weak electrolytes dissociate incompletely, or do not fully separate into their respective ions. A 1.0 M solution of a weak electrolyte "CD" may contain less than 0.20 M "C^+" ions, the same molarity of "D^-" ions, and greater than 0.80 M "CD" molecules. In a solution of a weak electrolyte the main substance present is the entire molecule, not necessarily the dissociated ions.

The dissociation of a weak electrolyte is an equilibrium process, in which molecules are constantly dissociating, a forward reaction, and reforming, the reverse reaction, at identical rates. At equilibrium, the forward and reverse processes occur at the same rate, so molecules dissociate and reform at the same rate, and the concentrations of the molecule, its positive ions and its negative ions all remain constant.

The probability of spontaneous dissociation of a molecule is constant, but the probability of reformation of the molecule from its ions depends on the concentration of ions present; low concentration makes reformation infrequent which makes the reverse reaction slower. This means that diluting a weak electrolytic solution slows down the reverse reaction more than it slows down the forward reaction. After dilution, dissociation outpaces reformation until the concentrations of the ions rise, their reformation rate increases, and the rate of the reverse reaction rises to match that of the forward reaction. As a result, dilution leads to dissociation of additional molecules before equilibrium is reached again. So diluting a 1.0 M solution of a weak electrolyte to 0.50 M with water reduces the conductivity, but by less than the 50% expected with strong electrolytes.

In this experiment, students will test the conductivity of a variety of strong, weak, and non-electrolyte solutions using a conductivity meter attached to an iWorx 214 data acquisition unit. Various electrolyte concentrations will also be studied to see how concentration affects conductivity.

Additional exercises may include relating conductivity to temperature, measuring the conductivity of water samples from a variety of sources, and correlating conductivity to pH.

The CM-100 Conductivity Probe is intended for water quality testing, general chemistry and ecology experiments. It has two switch selectable ranges of 0-200 and 0-20,000 microsiemens.

Specifications

Specifications	
Range:	0-200, 0-20,000 microsiemens

Operating Instructions:

Exercise 1: The Conductivity of Various Electrolytes.

Aim: To determine the conductivity of different electrolyte solutions.

Procedure:

Note:*Always begin testing samples with the conductivity selector switch in the 0-200 uS range. While recording the conductivity of each test sample, toggle the switch to the 0-20,000 uS position. This is especially important for measuring solutions with higher conductivities.*

1. Fill a 100 ml beaker with approximately 50 ml of 0.05M NaCl. Fill a 250 ml beaker with 100ml deionized water.
2. Make sure the conductivity selector switch is in the 0-200 uS position.
3. With the CMN-100 conductivity meter in the beaker of deionized water, Record Data.
4. When the recording on the Conductivity channel reaches a stable baseline, Record the value as conductivity of water.
6. Remove the meter from the deionized water and carefully blot the tip.

7. Place the CM-100 in the beaker of 0.05 M NaCl.
8. When the recording on the Conductivity channel reaches a stable baseline, Record the value as Conductivity of 0.05M NaCl

Note: *You may need to toggle the conductivity selector switch to the 0-20,000 uS range to get an accurate reading of conductivity.*