

Conductivity Lab

Chemistry 12

Introduction:

At swimming pools, swimmers must leave the water for a period of time after nearby lightning strikes. Why is this so? What is special about water that we are concerned about when electricity is around? What kinds of liquids would this not be true for? Does distilled water have this same status?

Consider the following:

- What do you see take place when a solute dissolves in a solvent? Does the solute disappear? How could you find out?
 - What physical process is occurring at the molecular level to result in what you see happening when something dissolves?
 - Does the same thing happen when all substances dissolve? Do salt and sugar both dissolve in the same way? How about all acids and all bases? Do they dissolve in the same way?

Substances that are capable of conducting an electric current in solution are known as electrolytes. Ionic compounds are electrolytes since they form positively and negatively charged ions in solution to conduct the electrical charges.

Electrolytes are divided into three substances: Acids, Bases, and Salts. Not all electrolytes conduct electricity to the same degree. Non-electrolytes are compounds that do not conduct electric currents in aqueous solutions. Most molecular (covalent) compounds are non-electrolytes since there are no positively and negatively charged ions in solution to conduct the electrical charges.

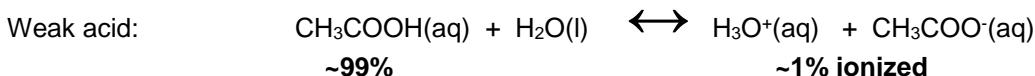
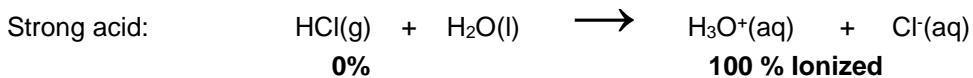
Electrolytes dissolve in water and dissociate, at least partially, into free ions. In a solution of electrolytes, several different species might be present, including intact molecules and dissociated ions. Strong electrolytes dissociate completely into ions. Weak electrolytes dissociate incompletely. Non-electrolytes do not dissociate at all. Strong electrolytes include strong acids, strong bases and soluble salts, while weak electrolytes include weak acids, weak bases and low-solubility salts. Non-electrolytes include all molecular (covalent) compounds.

Strong and Weak Electrolytes

a) Acids

Acids ionize or dissociate in aqueous solution to produce hydronium ions (H_3O^+ (aq)). The strength of an acid depends on the amount it ionizes or dissociates. Strong acids ionize almost completely, while weak acids ionize to a much lesser degree.

Examples:



Note: The dissociation of a substance with complete ionization is shown with a single forward arrow, while the dissociation of a substance with a low % ionization is shown with a double arrow.

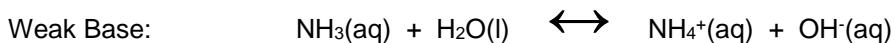
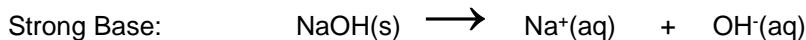
See animation below for illustration of a strong vs. weak acid ionizing in water:

http://preparatorychemistry.com/Bishop_Water_frames.htm (choose 'acid animation' from the menu)

b) Bases

Bases ionize or dissociate in aqueous solution to produce hydroxide ions (OH^- (aq)). The strength of a base depends on the amount it ionizes or dissociates. Strong bases ionize almost completely, while weak bases ionize to a lesser degree.

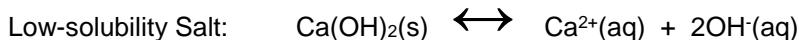
Examples:



c) Salts

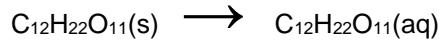
Salts dissociate in aqueous solution to produce a positive metal ion and a negative non-metal ion. Soluble salts dissociate almost completely, while low-solubility salts dissociate to a lesser degree. A table of solubilities (included) allows you to determine the solubilities of many salts.

Examples:

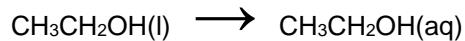


Non-Electrolytes

Sucrose, or table sugar, is a non-electrolyte. Its molecules remain intact when dissolved in water as shown in the equation below:



Ethanol is also a non-electrolyte as shown in the following equation:



A circuit can be created to test the conductivity of various solutions. Conductivity can be measured using a variety of both qualitative and quantitative conductivity meters. The conductivity of a solution is dependent upon the type of solute, the concentration of the solution and the movement of free ions in solution. The number of free ions in solution and thus the amount of current flowing is indicated by the brightness of the bulb (qualitative), or the conductivity value – measured in Siemens/cm (quantitative). In this lab you will use a conductivity bulb to measure only the qualitative differences between strong and weak electrolytes and non-electrolytes.

Purpose:

In this experiment, you will construct a conductivity tester and study the electrical conductivity of water and various water solutions. You will then identify the solutions as electrolytic and non-electrolytic, and identify variations in conductivity among electrolytes.

Materials:

1. 100 ml beakers
2. light bulb apparatus to detect conductivity or conductivity probes
3. Analytical balance

Reagents: suggested solutions should be 1.0 M

Note: some of these reagents may have been substituted with another solution.

Hydrochloric acid

sodium hydroxide

copper(II) chloride

sodium chloride

potassium iodide

acetic acid

ammonium hydroxide

sugar (glucose or sucrose)

methanol (or ethanol)

isopropyl alcohol

distilled water

ammonia

Procedure:

Prepare 25.0 mL of 1.0M solutions for each solid and concentrated solution.

Pour approximately 20 mL of one solution into a 100 mL beaker and test its conductivity. Record your observations.

Repeat for each of the other solutions.

Data and Observations:

For each solution tested, record the conductivity in ppm or A. The handheld meter gives values in ppm and the ammeter gives values in A.

Questions (answer in complete sentences on a separate piece of paper):

1. Which compounds were ionic?
2. Which compounds were molecular?
3. Which compounds were nonelectrolytes
4. Which compounds were electrolytes?
5. What effect would concentration have on the conductivity of a substance?
6. Describe the difference (macroscopically) between an ionic compound and a molecular compound?
7. Draw microscopically what happens to an ionic and a molecular compound when dissolved in water.
8. Explain why some materials are strong, weak or non-conductors.
9. What are the predominant and minor (if any) species present in each of the solutions tested?
10. What trend might you observe if you tested the conductivity of NaCl, CaCl₂, and AlCl₃ solutions? Explain why a trend might be observed.
11. Explain why 5 mol/L HC₂H₃O₂ would conduct electricity but pure HC₂H₃O₂ (called glacial acetic acid) would not.
12. Which would have more ions: 1.0 mol/L HCl or 5 mol/L HC₂H₃O₂? How could you find out?
13. Write an operational definition for 'electrolyte'. What is the difference between an electrolyte and a non-electrolyte?
14. If you were caught in a thunderstorm, which of the solutions tested would you least like to be standing in?
15. What would happen to the conductivity of a substance if you dilute its solution with water?

Summary:

In this experiment, students discovered some properties of strong electrolytes, weak electrolytes, and non-electrolytes by observing the behavior of these substances in aqueous solutions. When the conductivity apparatus is placed in a solution that contains ions, and thus has the ability to conduct electricity, an electrical circuit is completed across the electrodes. This complete circuit causes the LED bulb to glow to varying degrees. The brightness of the light depends on the ability of the aqueous solution to conduct electricity. Strong electrolytes produce large numbers of ions, which results in a very bright light. Weak electrolytes result in low conductivity and thus a dim light and non-electrolytes should result in no conductivity and thus will not cause the LED light to glow at all.