Experiment 5
<u>Properites of Solutions: Electrolytes and Non-electrolytes</u>

Purpose

In this experiment, you will discover some properties of strong electrolytes, weak electrolytes, and non-electrolytes by observing the behavior of these substances in aqueous solutions. You will determine these properties using a conductivity probe. When the probe is placed in a solution that contains ions, and thus has the ability to conduct electricity, an electrical circuit is completed across the electrodes that are located on either side of the hole near the bottom of the probe body (see Figure 1). This results in a conductivity value that can be read by the computer. The unit of conductivity used in this experiment is the microsiemens per cm, or µS/cm.

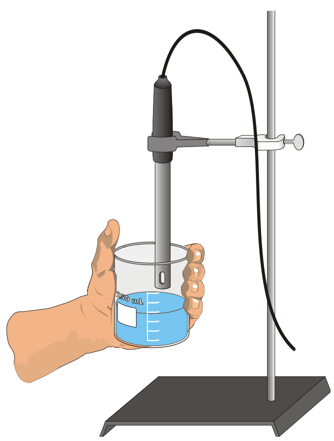

Figure 1

You will use a vial containing the sample (instead of a beaker, as shown above). The contents of the vial will be reused by others, so **<u>it is critical that contamination is prevented</u>.**

Make sure you rinse the probe between measurements with distilled water.

The size of the conductivity value depends on the ability of the aqueous solution to conduct electricity.

Strong electrolytes produce large numbers of ions, which results in higher conductivity values.

Weak electrolytes result in lower conductivity values.

Non-electrolytes should result in relatively no conductivity.

In this experiment, you will observe several factors that determine whether or not a solution conducts, and if so, the relative magnitude of the conductivity. Thus, this simple experiment allows you to learn a great deal about different compounds and their resulting solutions.

PROCEDURE

1) Obtain and wear goggles! **CAUTION:** *Handle the solutions in this experiment with care. Do not allow them to contact your skin. Notify your teacher in the event of an accident.*

2) Prepare the computer to monitor conductivity. Turn on the laptop and connect the conductivity probe to the Logger Pro interface box. **Make sure the conductivity meter is set on the 0-20,000 μS position.**

3) On the computer screen, open Logger Pro software and in the **File**>**Open**>***Chemistry with Vernier*** folder, find Exp 13 Electrolytes. The meter window will display live conductivity readings, in units of microsiemens (μS/cm). Make sure you are observing readings. If you are not, notify your instructor.

   Record the readings you obtain while the probe is in the air. You do not necessarily have to subtract this value from all subsequent readings, but keep this background reading in mind.

   Background conductivity = ______________ μS/cm

4) There are 9 solutions provided, plus two samples you can obtain at your station. Please share with the class by only taking three at a time. The solutions are all 0.05 M (same concentration) of:

   NaCl, H_3PO_4, $HC_2H_3O_2$ (also written as CH_3COOH), H_3BO_3, $C_2H_6O_2$, $CaCl_2$, CH_3OH, HCl, and $AlCl_3$.

   In addition, you should also obtain tap water and distilled water samples for a **total of 11 samples**. You may also test any samples you happen to have with you (bottled water, vitamin water, etc...)

5) Measure the conductivity for each of the solutions.

   - Carefully raise each vial and its contents up around the conductivity probe until the hole near the probe nd is completely submerged in the solution being tested. **Important:** Since the two electrodes are positioned on either side of the hole, this part of the probe must be completely submerged as shown in Figure 1.

   - Briefly swirl the beaker contents. Once the conductivity reading in the Meter window has stabilized, record the value in your data table.

   - Before testing the next solution, clean the electrodes by surrounding them with a 250-mL beaker and rinse them with distilled water from a wash bottle. Blot the outside of the probe end dry using a tissue. It is *not* necessary to dry the *inside* of the hole near the probe end.

Waste Disposal
Rinses may go down the sink.

 Name__________________________ Section_______

Experiment 5 Turn-in sheets

Properties of Solutions: Electrolytes and Non-electrolytes

Data

Don't forget units. **Please use permanent ink**.

Solution	Conductivity (µS/cm)
A - $CaCl_2$	
A - $AlCl_3$	
A - NaCl	
B - $HC_2H_3O_2$	
B - HCl	
B - H_3PO_4	
B - H_3BO_3	
C - $H_2O_{distilled}$	
C - H_2O_{tap}	
C - CH_3OH	
C - $C_2H_6O_2$	

Follow-up Questions

1. a) What do you notice about how your Group A conductivity values? In comparison to all the data collected (Groups A, B, and C), do Group A compounds appear to be relatively strong, weak, or non-electrolytes?

   If they appear to be electrolytes, write a balanced equation for the dissociation of each of your Group A compounds.

   (Note: Chloride ion is a *monatomic* ion... use only Cl^-, not Cl_2^{2-} or Cl_3^{3-}!)

   b) Explain why there is some variation in conductivity within the Group A compounds. Can it be explained by the chemical equations written above?

2. a) Do Group B compounds have conductivity values in agreement with each other, the way Group A compounds did? What categories apply to Group B compounds: Strong electrolytes, weak electrolytes, non-electrolytes?

   b) Group B compounds are molecular acids. Is it correct to assume complete dissociation for all acids? Using the conductivity value for each acid, determine which acids should be considered strong, weak, and non-electrolytes.

c) How would you classify phosphoric acid, H_3PO_4? Is it easy to classify it as a strong, weak, or non-electrolyte, based only on its conductivity value?

d) Consider the conductivity value for hydrochloric acid. How many ions dissociate for each hydrochloric acid molecule, assuming complete dissociation? Is there evidence for complete dissociation? Explain.

e) Now consider the number of ions that dissociate for each phosphoric acid molecule, assuming complete dissociation. Is there evidence for complete dissociation, relative to hydrochloric acid? Thus, how would you classify phosphoric acid?

f) Can you tell whether an acid will be a strong, weak, or non-electrolyte based on its chemical formula? Explain.

3. Examine Group C compounds. How do you explain their low conductivity values? Is there a way to predict whether a compound will be a nonelectrolyte based on its chemical formula?

4. How do you explain the relatively high conductivity of tap water compared to a low or zero conductivity for distilled water? If you didn't see this in your results, explain why you should have.

5. Hydroxides are OH^- ions. Alcohols are compounds that contain O—H bonds but not as hydroxide ions. Should CH_3OH be considered a hydroxide (ionic compound) or an alcohol (molecular compound) based on its conductivity value? Explain.

 Name__________________________ Section_______

Pre-Lab Assignment

Read the background information. If you need a refresher, try reading Chapter 4 in your textbook on compounds.

1) Define strong electrolyte, weak electrolyte, and nonelectrolyte. How do they differ in the number of ions they produce when dissolved in solution?

2) List what ions you expect to find for each of the following electrolytes (include the correct charges—and you need to recognize **polyatomic ions** if they are present). Polyatomic ions are conveniently located on Page *iv* of this lab manual.

a) CaF_2

b) NH_4Cl

c) Na_3PO_4

3) Each ionic compound above dissociates into ions. How many total ions result from each compound, assuming complete dissociation? (For example, NaCl dissociates into two ions.)

4) Assuming you had the same concentration of each compound above and they dissociated completely, which would you expect to be the strongest electrolyte(s)? Weakest? Explain.