Name:____________________ Section Number:____________ Score:________

Properties of Solutions: Electrolytes and Non-Electrolytes

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 LabQuest. The unit of conductivity used in this experiment is the microsiemens per centimeter, or µS/cm.

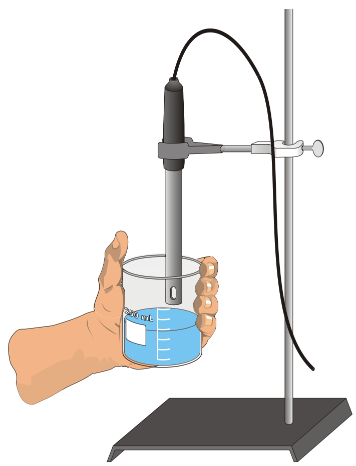

Figure 1

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 high conductivity values. Weak electrolytes result in low conductivity, and non-electrolytes should result in 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.

In each part of the experiment, you will be observing a different property of electrolytes. Keep in mind that you will be encountering three types of compounds and aqueous solutions:

Ionic Compounds

These are usually strong electrolytes and can be expected to 100% dissociate in aqueous solution.

Example: $NaNO_3(s) \longrightarrow Na^+(aq) + NO_3^-(aq)$

Molecular Compounds

These are usually non-electrolytes. They do not dissociate to form ions. Resulting solutions do not conduct electricity.

Example: $CH_3OH(l) \longrightarrow CH_3OH(aq)$

Molecular Acids

These are molecules that can partially or wholly dissociate, depending on their strength.

Example: Strong electrolyte $H_2SO_4 \longrightarrow H^+(aq) + HSO_4^-(aq)$ (100% dissociation)

Example: Weak electrolyte $HF \longleftrightarrow H^+(aq) + F^-(aq)$ (<100% dissociation)

OBJECTIVES

In this experiment, you will

- Write equations for the dissociation of compounds in water.
- Use a Conductivity Probe to measure the conductivity of solutions.
- Determine which molecules or ions are responsible for conductivity of solutions.
- Investigate the conductivity of solutions resulting from compounds that dissociate to produce different numbers of ions.

MATERIALS

LabQuest	0.05 M NaCl
LabQuest App	0.05 M $CaCl_2$
Vernier Conductivity Probe	0.05 M $AlCl_3$
ring stand	0.05 M $HC_2H_3O_2$
utility clamp	0.05 M H_3PO_4
250 mL beaker	0.05 M H_3BO_3
wash bottle and distilled water	0.05 M HCl
tissues	0.05 M CH_3OH (methanol)
H_2O (tap)	0.05 M $C_2H_6O_2$ (ethylene glycol)
H_2O (distilled)	

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. Assemble the Conductivity Probe, utility clamp, and ring stand as shown in Figure 1. Be sure the probe is clean and dry before beginning the experiment.

3. Set the selector switch on the side of the Conductivity Probe to the 0–20000 µS/cm range. Connect the Conductivity Probe to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.

4. Obtain the Group A solution containers. The solutions are: 0.05 M $CaCl_2$, 0.05 M NaCl, and 0.05 M $AlCl_3$.

5. Measure the conductivity of each of the solutions.
   a. Carefully raise each vial and its contents up around the Conductivity Probe until the hole near the probe end 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.
   b. Briefly swirl the vial contents. Monitor the conductivity reading displayed on the screen for 6–8 seconds, then record the value in your data table.
   c. 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.
6. Obtain the four Group B solution containers. These include 0.05 M $HC_2H_3O_2$, 0.05 M HCl, 0.05 M H_3PO_4, and 0.05 M H_3BO_3. Repeat the Step 5 procedure.
7. Obtain the four Group C solutions or liquids. These include distilled H_2O, tap H_2O, 0.05 M CH_3OH, and 0.05 M $C_2H_6O_2$. Repeat the Step 5 procedure.

DATA TABLE

Solution	**Conductivity (µS/cm)**
A - 0.05 M NaCl	
A - 0.05 M $CaCl_2$	
A - 0.05 M $AlCl_3$	
B - 0.05 M $HC_2H_3O_2$	
B - 0.05 M H_3PO_4	
B - 0.05 M H_3BO_3	
B - 0.05 M HCl	
C - H_2O (tap)	
C - H_2O (distilled)	
C - 0.05 M CH_3OH (methanol)	
C - 0.05 M $C_2H_6O_2$ (ethylene glycol)	

PROCESSING THE DATA

1. Based on your conductivity values, does the Group A compounds appear to be molecular, ionic, or molecular acids? Would you expect them to partially dissociate, completely dissociate, or not dissociate at all?

2. Why do the Group A compounds, each with the same concentration (0.05 M), have such large differences in conductivity values? **Hint:** Write an equation for the dissociation of each. Explain.

3. In Group B, do all four compounds appear to be molecular, ionic, or molecular acids? Classify each as a strong or weak electrolyte, and arrange them from the strongest to the weakest, based on conductivity values.

4. Write an equation for the dissociation of each of the compounds in Group B. Use $\longrightarrow$ for strong; $\longleftrightarrow$ for weak.

5. For H_3PO_4 and H_3BO_3, does the subscript "3" of hydrogen in these two formulas seem to result in additional ions in solution as it did in Group A? Explain using chemical equations.

6. In Group C, do all four compounds appear to be molecular, ionic, or molecular acids? Based on this answer, would you expect them to dissociate?

7. How do you explain the relatively high conductivity of tap water compared to a low or zero conductivity for distilled water?