Electrolytes

Electrolytes are important in the body for proper function, nerve conduction. When the supply of electrolytes in the body is depleted due to physical activity or illness, electrolyte solutions are administered to restore a balance of electrolytes. Athletes choose to rehydrate with drinks containing electrolytes, such as Gatorade. Pedialyte solutions are given to children. And, saline solutions are used in medical situations to restore a balance of electrolytes in patients suffering from various ailments.

Electrolytes are chemical substances that when dissolved in water yield solutions of charged particles called ions. Some electrolytes dissociate (split apart) into the ions present in the original substance. In contrast, some substances are electrolytes even though the substance does not originally contain ions, but instead because ions are produced via chemical reactions when the substance is dissolved in water.

Some electrolytes dissociate or ionize completely and are called strong electrolytes. In this case, the chemical process or reaction is considered to proceed only in the forward direction to entirely produce the product ions (the reaction has a high equilibrium constant).

<center>strong electrolyte ⇨ ions</center>

Some chemical processes or reactions can occur in both a forward and a reverse direction – meaning that reactants produce products, but also products produce reactants (the reaction has a low equilibrium constant). This scenario occurs with weak electrolytes and explains why complete dissociation or ionization does not occur for these substances.

<center>weak electrolyte ⇔ ions</center>

If a substance does not yield a solution of ions, it is a nonelectrolyte.

In this experiment, you will discover some properties of strong electrolytes, weak electrolytes, and nonelectrolytes 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: Conductivity Probe). 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.

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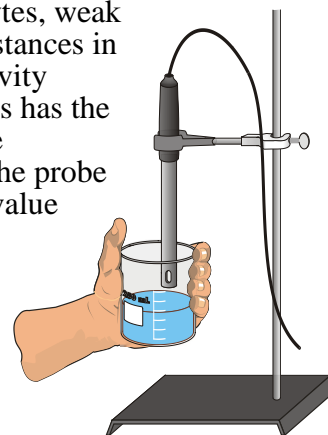

Figure 1: Conductivity Probe

Make sure you rinse the probe between measurements with distilled water (use a wash bottle). Set up a waste beaker at your station to collect the rinses between readings. At the end of lab, you may dispose of the contents of the waste beaker in the sink with plenty of extra water from the tap.

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.

Nonelectrolytes 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.

Read the section in your textbook on electrolytes (search the index for page numbers).

HAZARDS

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.*

PROCEDURE

1) Prepare the computer to monitor conductivity. Turn on the laptop and connect the conductivity probe to the Logger Pro interface box. **Flip the switch on the conductivity meter (black box) so that it is set to the 0-20,000 μS position.**

2) On the computer screen, open Logger Pro software. Open the file called **Exp 13 Electrolytes by selecting File**>**Open**>*Chemistry with Vernier* and then search for the file.

   The meter window will display live conductivity readings, in units of microsiemens (μS/cm). Make sure you are observing readings. If you are not, you have not selected the correct file.

3) Observe the readings you obtain while the probe is in the air. This is the background conductivity. Record a value for the background conductivity in μS/cm. Comment on the precision of the conductivity meter. (Is the value constant or not? How many significant figures should be recorded? What would you estimate the +/- error to be for this device?

   You do not necessarily have to subtract this value from all subsequent readings, but keep this background reading in mind.

4) There are 9 solutions provided, plus two samples you can obtain at your station; they are grouped into group A, B, or C. Please share with the class by only taking three at a time to your table. The solutions are all 0.05 M (same concentration) of:

   Group A: NaCl, $CaCl_2$, $AlCl_3$

   Group B: H_3PO_4, $HC_2H_3O_2$ (also written as CH_3COOH), H_3BO_3, HCl

   Group C: $C_2H_6O_2$ CH_3OH, tap H_2O, distilled H_2O.

   You should have a **total of 11 samples**. You may also test any samples you bring to class to test (e.g., cola, coffee, bottled water, vitamin water, etc…)

   Create a data table that is set up to record the solution group (A, B, C), the identity of the solution, and the corresponding conductivity value that you will measure.

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 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 as shown in Figure 1.

- Briefly swirl the vial contents. Once the conductivity reading on the meter display 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 ChemWipe tissue. It is *not* necessary to dry the *inside* of the hole near the probe end.

WASTE
Rinses in your waste beaker may go down the sink with plenty of extra water from the tap.

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REPORT SHEETS
Electrolytes

1. a) Do Group A compounds appear to be relatively strong, weak, or nonelectrolytes, compared to Group B and C?

   b) 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-}!)

   $$H_2O \ (l)$$

   Example: $LiCl \ (s)$ $\rightarrow$ $Li^+ \ (aq)$ + $Cl^- \ (aq)$
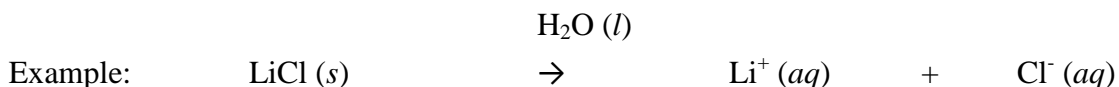
   c) Explain why there is some variation in conductivity within the Group A compounds. Can it be explained by the chemical equations you wrote above? Explain.

2. a) Group B compounds are molecular acids. Is it correct to assume complete dissociation for all acids? Explain.

   b) List the acids in Group B in order of increasing conductivity values (provide the values). Label them as "strong electrolytes", "weak electrolytes" and "non-electrolyte" based on the values.

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

d) Write the dissociation equation for hydrochloric acid and its conductivity value. How many ions dissociate for each hydrochloric acid molecule, assuming complete dissociation? Is there evidence for complete dissociation?

e) Write the dissociation equation for phosphoric acid and its conductivity value. How many ions dissociate for each phosphoric acid molecule, assuming complete dissocation? 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 nonelectrolyte based solely on its chemical formula? Explain using conductivity values from this lab to support your answer.

3. Examine Group C compounds. How do you explain their low conductivity values?

4. What types of bonds are in the following compounds? (Circle ionic or covalent). Are these groups electrolytes or nonelectrolytes or both (circle your answer choices)?

	Type of Bond:		Classification:		
Group A	ionic	covalent	electrolytes	nonelectrolytes	both
Group B	ionic	covalent	electrolytes	nonelectrolytes	both
Group C	ionic	covalent	electrolytes	nonelectrolytes	both

5. You are advised not to use electrical applicances in the bath tub. Using concepts from this lab, explain why.

6. Should CH_3OH be considered a hydroxide (ionic compound) or an alcohol (molecular compound) based on its conductivity value? Circle your choice and **explain**.
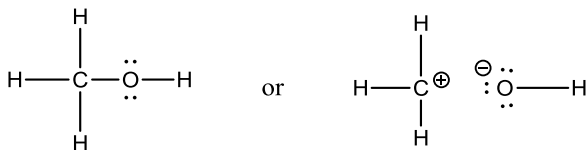
covalent/molecular   or   ionic

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Pre-Lab Assignment
Electrolytes

Read the background information. If you need more information, read the chapter on compounds and bonding and electrolytes. Have a periodic table with monatomic ions and a list of polyatomic ions on hand for this assignment. See the CHEM& 161 website for a link

Set up your lab notebook according to the Laboratory Notebook Guidelines!

1) Define strong electrolyte, weak electrolyte, and nonelectrolytes in terms of their conductivity and 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 the correct number of each ion. You will need to recognize **monatomic and polyatomic ions** if they are present; refer to the tables in your textbook. (For example, NaCl dissociates into Na^+ and Cl^-.)

         a) CaF_2

         b) NH_4Cl

         c) Na_3PO_4
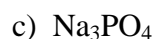
3) Each ionic compound above dissociates into ions. How many total ions result from each compound, assuming complete dissociation? (For example, NaCl dissociates into two ions.)

         a) CaF_2

         b) NH_4Cl

         c) Na_3PO_4
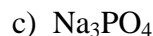
4) Assuming you had the same concentration of each compound above and they dissociated completely:

(a) Which would you expect to be the strongest electrolyte?

(b) Which would you expect to be the weakest? **Explain.**