CHM 130LL: Electrolytes Lab

Introduction

Electrolytes are substances that conduct electricity in solution. In this experiment, you will use a conductivity tester to determine whether substances are strong, weak, or non-electrolytes. The conductivity tester has **red and green LEDs that will light up if a solution contains ions that will conduct electricity. Ions can carry electricity across a solution between the electrodes.**

A strong electrolyte will completely dissociate into ions in solution and will cause a strong or bright light. A weak electrolyte will only dissociate to a small degree. Only a small percentage of the compounds will dissociate into ions but most will stay together as intact molecules, and a weak light will be seen. Non-electrolytes will **not** dissociate into ions at all and will not conduct electricity. It is important to know the difference between **ionic and covalent compounds** in this lab. Ionic compounds are generally metal cations bonded with nonmetal anions. Covalent compounds are composed of nonmetal atoms covalently bonded together.

Background

The best everyday example of an electrolyte is Gatorade™ or any similar sports drink. When you exercise, you lose electrolytes through sweat. In order to maintain normal cell function, it is crucial that those electrolytes be replaced. Electrolytes are used by your body to regulate functions such as heartbeat, brain function, and muscle control. The most common electrolytes that must be kept in balance in your body are sodium, potassium, magnesium, calcium, chloride, and bicarbonate.

Sodium is responsible for regulating the electrical signals to your brain, muscles, and nervous system. Most of your body's fluid (outside the cells; e.g., blood and urine) is high in sodium. It is possible to have too much sodium (hypernatremia) or too little sodium (hyponatremia) in your system.

Potassium is the major electrolyte found in cells. One of the main roles of potassium is in the regulation of your heartbeat and muscle function. It is common for athletes who are experiencing muscle cramps to consume potassium (bananas are a great source). Like sodium, it is possible to have increased potassium levels (hyperkalemia) or decreased potassium levels (hypokalemia). Potassium is not lost as rapidly as sodium since it is inside cells.

Chloride is also a major electrolyte in the body. Like sodium it is found mainly in body fluids outside the cells. Human body fluids have almost the same concentration of chloride ions as sea water. Bicarbonate acts as a buffer in the body to help control the pH of your blood and other fluids.

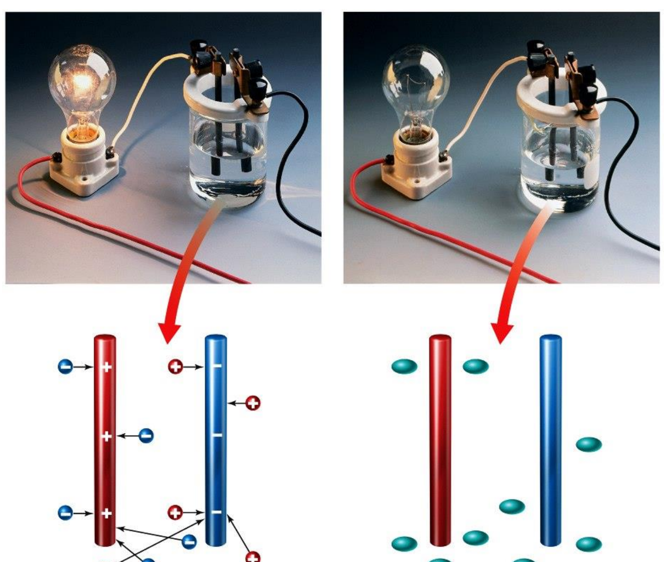
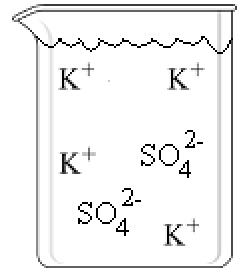


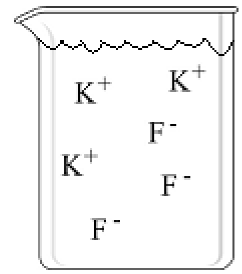
Figure 1 to the right illustrates the difference between an electrolyte (left picture) and a non-electrolyte (right picture).

Picture from McMurry/Fay 5th edition, Pearson

Understanding solubility rules: Water is commonly used as a solvent in solutions. When a substance is soluble in water, it is said to be aqueous. The notation (aq) is used for the physical state and specifically means that substance will dissolve in water. Solubility rules for ionic compounds are on your Periodic Table. If an ionic compound will dissociate, or break into ions, it is soluble. If is will not break into ions then it is said to be largely insoluble (very few ions form.) When an ionic compound with a polyatomic ion dissociates and breaks into ions, the polyatomic ion stays together. For example, in potassium sulfate, K_2SO_4 which is soluble, the ions are two K^+ and one SO_4^{2-} ions. See the beaker above. Do not separate the S and O atoms in sulfate ion.

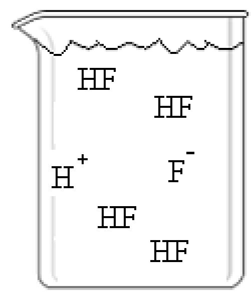


Strong electrolytes: A strong electrolyte will completely dissociate (break apart) into ions in solution and will cause a strong or bright light. Soluble ionic compounds are strong electrolytes. One example is potassium fluoride (KF) dissolved in water. If you check the solubility rules on your Periodic Table, potassium ions are always soluble. This means that potassium compounds will always break apart completely (100%) into ions in water. We can represent this as shown in the picture to the right. (Also see the left image in Figure 1.) Notice that once the solid is placed in water it breaks apart into separate ions that have charges. These charges help us write the correct chemical formula for ionic compounds. Strong acids and bases are also strong electrolytes.



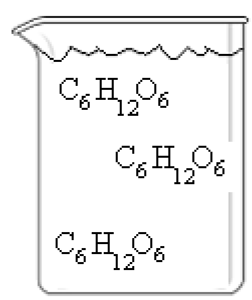
Watch the movie at this link (http://www.wou.edu/las/physci/ch412/hydrolysis.htm) to see an animation of sodium chloride dissolving in water.

Weak electrolytes fall between strong and non-electrolytes. Weak acids and bases are the most common examples of weak electrolytes. Insoluble ionic compounds are also weak electrolytes as they are very slightly soluble in water, and dissociate into a few ions. As you might guess, these will usually give a weak light when placed in a conductivity tester. The reason is that these substances will dissociate into ions to a small degree (1-5%). Since most of the compounds will stay together in molecular form, there aren't as many ions floating around in solution. Therefore, they can only conduct electricity to a small degree, and that is why a weak light is seen. Notice in the drawing of hydrofluoric acid on the right how only one molecule out of five (or 20%) is dissociated into ions. In reality, most weak acids and bases only dissociate about 1-5%.



Watch the animation at this link to see a strong acid versus a weak acid ionizing in water.
http://www.mhhe.com/physsci/chemistry/animations/chang_2e/acid_ionization.swf

Non-electrolytes do not break apart into ions. These substances are usually covalently bonded molecules (non-metal + non-metal like $C_6H_{12}O_6$). Water molecules are not strong enough to pull the compounds apart into ions and therefore they will not conduct electricity. (See the right image in Figure 1.) The image to the right illustrates what you would see if you could zoom in to the atomic level. Notice that the molecules stay intact in the beaker: there are no ions at all. They are not broken apart by water. Also notice that this is a covalent molecule.



Summary: In general:

Strong Electrolytes – strong acids, strong bases, **soluble ionic** compounds
Weak Electrolytes – weak acids, weak bases, **insoluble ionic** compounds
Non-Electrolytes – molecular or **covalent** compounds

Procedure: Half of the lab (in pairs) will measure electrolytes while the other half (again in pairs) works on the post lab questions.

Part I – Determining strengths of electrolytes

1. Make sure the well plate is clean and dry. (It is crucial that the wells are clean and dry because any contamination will give incorrect results.)
2. Notice that each row on the well plate is labeled with letters and each column is labeled with numbers. This makes it possible to identify which substance is in which well (ex: A3 or C2). In your data table (on the next page), **write which well you will place each substance in.**
3. For the solid salt (NaCl) and solid sugar ($C_{12}H_{22}O_{11}$) use those bottles to carefully fill two wells about ½ full of each solid making sure no crystals spill over into a different well. Do NOT add water to these two solids. All the other substances you will test are already dissolved in DI water, so they are aqueous solutions. For these solutions place 20 drops of each solution into a well. You will test silver chloride solution in a separate vial at the instructor station, take your conductivity tester to the instructor station – make sure you test the silver chloride in the brown vial at the instructor station, do NOT pour it into your well plate.
4. Connect the 9-volt batter to the conductivity tester and make sure it is snapped into place (you should hear a click when it is fully connected). Turn the tester "On" and notice the LED lights are not lit. (When you are finished today make sure you disconnect the battery)
5. To test each solution or solid, place both electrodes in the well. Record your observations of both LED lights in your data table. For a very strong electrolyte, you should see both red and green LED's light up. You may need to use your hand to shade the LED's from the overhead lights to be sure.
6. **After testing one substance**, turn the tester off, rinse the electrodes with DI water into a waste beaker, and carefully wipe the electrodes with a Chem wipe. Now you may test the next one.
7. Save your substances until you are sure of your results. You might have to measure conductivities several times to determine the appropriate value on the scale.
8. Once you have double-checked your LED lights, assign conductivity values and scale numbers on your report sheet according to the table below. The back of the conductivity tester also shows the conductivity reading based on the LED brightness.
9. When you are finished, **dump your well plate into the waste jar**. Then rinse it with tap water followed by a little DI water. Dry the well plate as well as you can.

Use the following conductivity scale to rate each substance.				
Red LED	**Green LED**	**Conductivity**	**Scale**	**Electrolyte**
Off	Off	Very low/none	0	Non
Dim	Off	Low	1	Non
Medium	Off or Dim	Medium	2	Weak
Bright	Dim	High	3	Weak
Very bright	Medium	Very high	4	Strong

Part II – Post lab questions. Draw the solutions based on the solubility rules, not based on your observations today, as some solutions may give a false positive result due to CO_2 from air dissolving into the solutions creating ions.

CHM 130LL: Electrolytes Lab Report

Name: ________________________________

Partner: _______________________________

Section Number: ______________

Part I Data:

Substance mixed with DI water unless noted	**Well Location**	**Red LED**	**Green LED**	**Conductivity**	**Scale**
Solid sodium chloride,(s)					
Solid sugar, $C_{12}H_{22}O_{11}$(s)					
Tap water					
Sodium chloride					
Sugar, $C_{12}H_{22}O_{11}$(aq)					
Hydrochloric acid, HCl(aq)					
Sodium hydroxide					
Acetic acid, $HC_2H_3O_2$(aq)					
Potassium iodide					
Calcium carbonate					
Fructose, $C_6H_{12}O_6$(aq)					
Silver chloride	Vial				

1. Which of the substances in Part I of today's lab are strong electrolytes?

2. Which of the substances in Part I of today's lab are weak electrolytes?

3. Which of the substances in Part I of today's lab are non-electrolytes?

Post-lab Questions:

1. Briefly explain why soluble ionic compounds are strong electrolytes.

2. Briefly explain why insoluble ionic compounds are weak electrolytes.

3. Describe what types of chemicals tend to be each of the following:

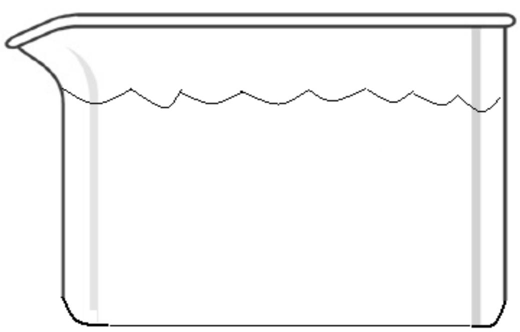
Strong electrolytes: ____

Weak electrolytes: ____

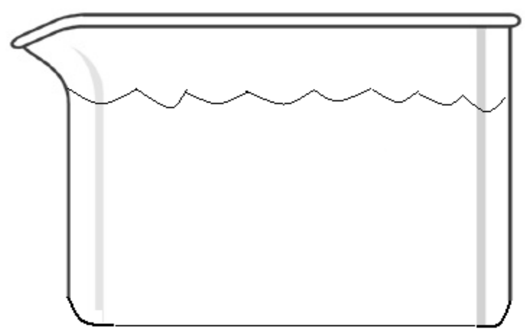
Nonelectrolytes: ____

4. For each substance below, write the formula of the substance on the line and then draw what you would see if could zoom in to the atomic level of the substance in DI water. (Similar to the drawings on page 2.) Use solubility rules, not your experimental results, to determine solubility.

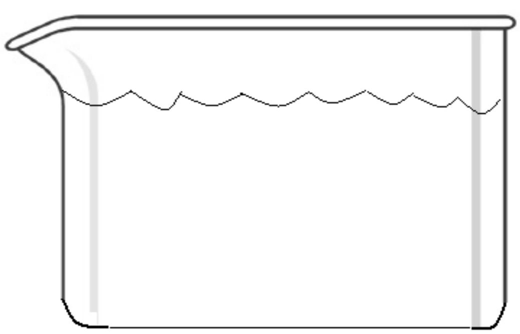
sodium chloride: _______________



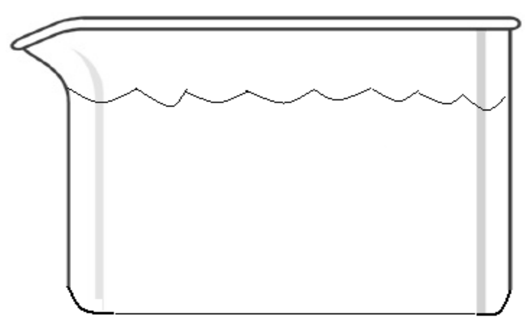
sugar: ___________________



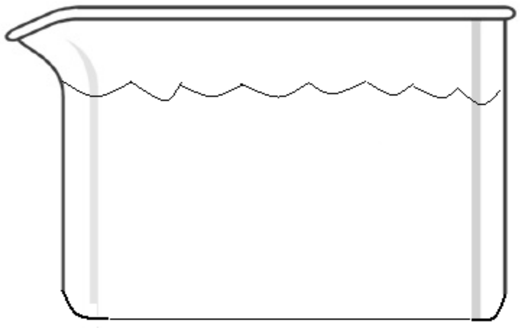
DI water alone: _____________________



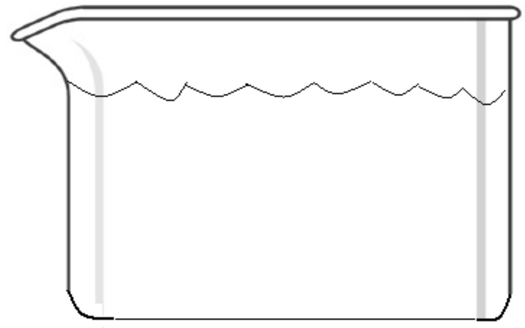
hydrochloric acid: _________________



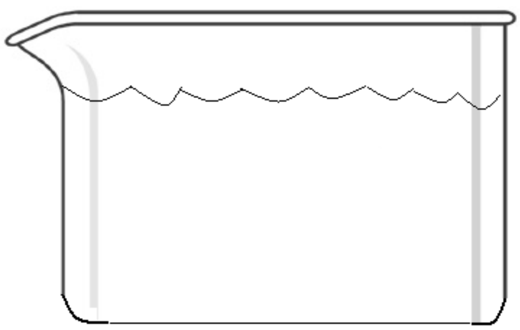
sodium hydroxide: _____________



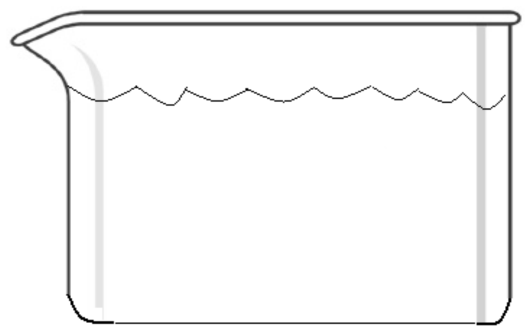
barium bromide: ____________________



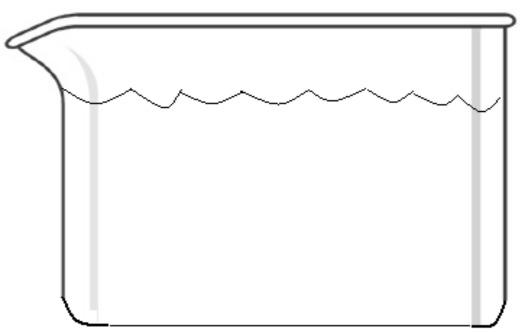
silver chloride,_______________



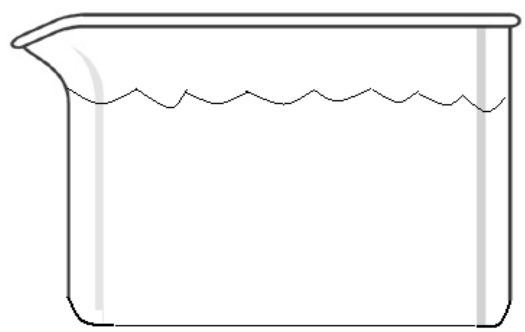
lead (II) iodide: ____________________



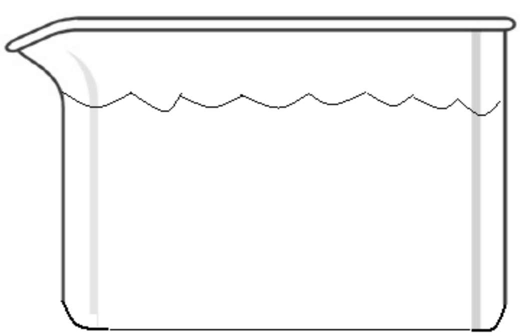
potassium iodide,_______________



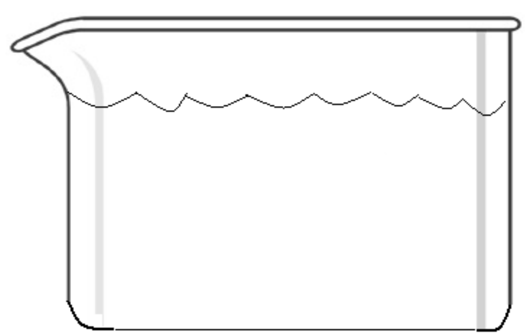
calcium carbonate: ____________________



fructose ,__________________



lithium sulfate: ____________________



5. For each of the following compounds, write the formula then predict whether it would be a strong, weak, or non-electrolyte when placed in DI water. For the ionic compounds only, put (s) or (aq) after the formula.

	Formula	Strong, weak or non electrolyte?
a. calcium hydroxide	________________________	________________________
b. silver carbonate	________________________	________________________
c. lead(II) sulfate	________________________	________________________
d. phosphorus trifluoride	________________________	________________________
e. sodium phosphide	________________________	________________________
f. barium sulfate	________________________	________________________
g. strontium acetate	________________________	________________________
h. zinc nitrate	________________________	________________________

6. Write the name for the following chemicals.

a. Na_2SO_4 ____________________________ e. $Mg(NO_3)_2$ ________________________________

b. KI ______________________________ f. $AuCl_3$ __________________________________

c. P_2S_5 ______________________________ g. $Cu(NO_2)_2$ _______________________________

d. N_2O_3 _____________________________ h. Li_2SO_3 __________________________________

7. Write the formula for the following chemicals.

a. Calcium phosphate __________________ e. Trinitrogen tetraoxide ______________________

b. Potassium sulfide ___________________ f. Magnesium acetate ________________________

c. Carbon dioxide _____________________ g. Nickel(III) cyanide ________________________

d. Cobalt(II) chloride __________________ h. Silver sulfate ____________________________