Experiment 3:
Electrolytes and Nonelectrolytes

Version 5
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In this experiment, you will study the conductivity of solutions of strong electrolytes, weak electrolytes, and non-electrolytes. You will also measure the pH and perform some tests that will allow you to observe chemical reactivity. To have a baseline or control, you will perform the same tests on deionized water. Then, you will study an unknown and compare results to identify it.

Objectives

- Discover some properties of strong electrolytes, weak electrolytes, and non-electrolytes by observing their behaviors in solutions.
- Write equations for the ionization of strong and weak electrolytes in water.
- Write equations for the dissolution of nonelectrolytes in water.
- Learn how to measure conductivity and pH.
- Compare concentration of hydronium ion produced by strong and weak acids.
- Observe precipitation reactions.
- Write the chemical formula of products formed from double replacement reactions.
- Determine identity of an unknown.

Learning Outcomes

- Understand the nature of units of measurement and apply rules for significant figures.
- Understand the nature of matter and its underlying physical and chemical characteristics.
- Understand the nature and characteristics of chemical bonds.
- Understand/apply the rules to write chemical formulas of ionic compounds.
- Employ conceptual learning outcomes and perform essential lab techniques in laboratory setting.

Definitions

- **Acids** – molecular compounds that are able to donate a hydrogen ion, H^+, when dissolved in water, thereby increasing the amount of free H^+ in the solution. They are written the hydrogen first to denote that the substance is an acid.
- **Aqueous solution** - a solution in which water the is the solvent
- **Conductivity** – the ability of a material to allow flow of electricity, heat, sound, ions, etc.; this experiment focuses on flow of electricity
- **Control** – the standard for comparison in an experiment; treated in the same way the experiment is performed but without the variable that is being tested
- **Dissociation** – the process of a solute mixing and dissociating (breaking apart into ions) within a solvent to form a solution
- **Dissolution** – the process of a solute mixing and dispersing within a solvent to form a solution
- **Electrolytes** – substances that conduct electricity when dissolved in water

- **Formula unit** – the smallest, electrically neutral collection of ions in an ionic compound
- **Ionic substance** – compound composed of cations and anions chemically bonded through electrostatic attraction
- **Ions** – atoms or a group of bonded atoms with a net charge
- **Ionization** – process of gaining or losing electrons to become an ion
- **Molarity, M** – unit of concentration; expressed as moles of solute per liters of solution, mol/L
- **Molecular substance** (also known as covalent substance) – compound composed of two or more nonmetals sharing electrons (covalently bonded)
- **Molecules** – smallest particle of a molecular compound that maintains the characteristics of the molecular compound (also applies to multi-atomic elements such as N_2 or S_8)
- **Nonelectrolytes** – substances that do not conduct electricity when dissolved in water because they do not ionize; molecular substances that are not acids or bases are nonelectrolytes
- **pH** – measurement of the concentration of hydrogen ions, H^+, in solution. The pH scale generally ranges from 0 to 14 (although concentrated acids and bases have values below and above this range). Neutral solutions have a pH of 7. A pH value below 7 means that the solution is acidic; the smaller the value the more acidic. A pH value above 7 means that the solution is basic; the larger the value the more basic.
    - $pH = -log(M_{H^+})$, where M = molarity
- **Precipitate** – solid, insoluble compound that forms in a solution and settles on the bottom of the container
- **Reagent** – chemical substance used to detect or measure the presence of another substance by causing a reaction
- **Solute** – the component in lesser amount in a solution
- **Solution** – a homogeneous mixture of solute(s) and solvent
- **Solvent** – the major component of a solution
- **Strong electrolytes** – substances that dissolve in water completely or almost completely, forming ions. They are good conductors of electricity. Ionic compounds (including strong bases) and strong acids are strong electrolytes.
- **Weak electrolytes** – substances that dissolve in water, but do not completely ionize and therefore only weakly conduct electricity in solution

Introduction

You work as a Quality Control (QC) Chemist for EverBrite, a manufacturer of over-the-counter products, such as EverBrite Toothpaste, EverBrite Insta-Denture Grip, and EverBrite Scalp Refreshing Anti-Dandruff Shampoo and Conditioner. As QC chemist, your day-to-day responsibilities include performing tests on raw materials, bulk formulations, finished products, stability samples, and any other samples from EverBrite's plant operations that require chemical analysis. You report to the QC Laboratory Supervisor.

The QC Lab Supervisor is upset because an old 55-gallon drum was found in the back of the warehouse with a partially torn label. The drum is about half-filled with a clear solution. While this is a serious violation of EverBrite's Storage and Traceability SOPs (Standard Operating Procedures), the problem is exacerbated because the FDA (Food and Drug Administration) is scheduled to visit the facility by the end of the week. The QC supervisor has given your QC team the responsibility of determining the identity of the solution so that it can be labeled and disposed of properly.

Fortunately, the receiving date on the label was still legible as well as the supplier's logo. After reviewing the Receiving Logs for that day, your team was able to narrow down the possible identity of the unknown solution to six solutions: 0.50 M glucose ($C_6H_{12}O_6$), 50 % isopropyl alcohol (C_3H_8O), 0.50 M acetic acid ($HC_2H_3O_2$), 0.50 M hydrochloric acid (HCl), 0.50 M magnesium sulfate ($MgSO_4$), and 0.50 M aluminum chloride ($AlCl_3$).

Your team will explore the characteristics of these eight solutions, referred to as known solutions from now on, and compare those characteristics with the unknown to determine its identity.

Electrolytes and Nonelectrolytes:

A solution is formed when a solute is dissolved in a solvent. The solute appears to disappear in the solvent, but if you watch closely, as more solute is added, the volume of the solution often increases. As the solute interacts with the solvent, the attractive forces within the solute (solute-solute attractions) compete with the attractive forces between the solute and the solvent. If this latter attraction (solute-solvent attraction) is stronger than the former, the solute particles disperse throughout the solvent. When this happens, we simply state that the solute dissolved.

Consider, for example, a molecular substance such as sucrose, $C_{12}H_{22}O_{11}$, commonly referred to as table sugar. From experience you know that table sugar is water-soluble, that is, it dissolves in water. Let's consider what happens to one teaspoon (4.2 grams) of sucrose, at the particulate level, when it dissolves in 1L of water. This sucrose sample contains 7.4 x 10^{21} molecules of sucrose:

$$?\,molecules\ C_{12}H_{22}O_{11} = 4.2\ g\ \times \frac{1\ mol}{342.296\ g} \times \frac{6.022 \times 10^{23} molecules}{1\ mol}$$

$$= 7.4 \times 10^{21}\ molecules\ C_{12}H_{22}O_{11}$$

As the solid dissolves, the sucrose molecules separate from one another and disperse throughout the water, but each sucrose molecule stays intact; each molecule continues to be chemically bonded within, and each has the chemical formula of $C_{12}H_{22}O_{11}$. We can represent this process with the following chemical equation:

$$C_{12}H_{22}O_{11}\ (s) \overset{H_2O}{\rightarrow} C_{12}H_{22}O_{11}(aq)$$

Where (s) means solid, and (aq) means aqueous solution.

Now consider what happens to an ionic substance such as sodium chloride, NaCl, commonly referred to as table salt. From experience, you also know that table salt is water-soluble. One teaspoon (5.7g) of sodium chloride contains 5.9 x 10^{22} formula units of NaCl:

$$?\,formula\ units\ NaCl = 5.7\ g\ \times \frac{1\ mol}{58.44\ g} \times \frac{6.022 \times 10^{23} formula\ units}{1\ mol}$$

$$= 5.9 \times 10^{22}\ formula\ units\ NaCl$$

Like sugar, as the solid salt dissolves, its formula units separate from one another; unlike sugar though, the formula units break apart freeing up the individual ions:

$$NaCl\ (s) \overset{H_2O}{\rightarrow} Na^{+}(aq) + Cl^{-}(aq)$$

So now there are actually 1.2×10^{23} free ions dispersed in the water:

$$total\ ions\ = 5.9 \times 10^{22}\ ions\ of\ Na^{+} + \ 5.9 \times 10^{22}\ ions\ of\ Cl^{-}\ = 11.8 \times 10^{22}\ ions$$
$$= 1.2 \times 10^{23}\ ions$$

Solutions of molecular substances, such as $C_{12}H_{22}O_{11}$, do not conduct electricity (see Figure 1a) therefore they are called nonelectrolytes, whereas solutions of ionic substances, such as NaCl, do conduct electricity (see Figure 1b). This type of substance, called electrolytes, conduct electricity because the dissolved ions act as charge carriers, allowing the solution to conduct electricity.[1]

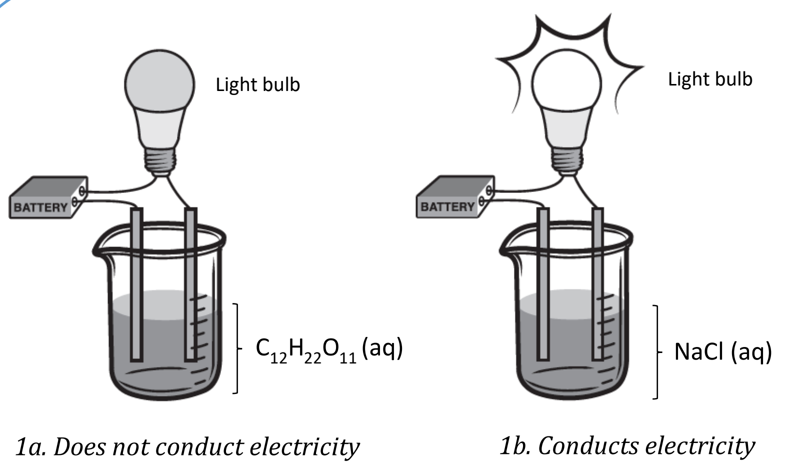

***Figure 1**. Behavior of two solutions in an open circuit*

Strong Electrolytes and Weak Electrolytes:

A strong electrolyte is a substance that dissociates or ionizes to a very large extent when dissolved in water. Sodium chloride and hydrobromic acid are examples of strong electrolytes. The process for the ionization of hydrobromic acid is represented in the following equation:

$$\text{HBr (aq)} \longrightarrow H^{+}(aq)\ + Br^{-}(aq)$$

A weak electrolyte is a substance that dissociates or ionizes to a relatively low percentage (<<100% ionization) when dissolved in water. Hydrofluoric acid, HF, is an example of a weak electrolyte. This process is represented in the following equation:

$$\text{HF (aq)} \rightleftharpoons H^{+}(aq)\ + F^{-}(aq)$$

Notice the difference in the <u>arrows</u> used in the equations of HBr and HF: we use equilibrium arrows (⇌) to differentiate a weak electrolyte from a strong electrolyte. Table 1 states which substances are electrolytes, and which are nonelectrolytes.

Table 1. Classification of Substances as Electrolytes and Nonelectrolytes

Nonelectrolytes	• Molecular substances that <u>are</u> <u>not</u> acids or bases
Electrolytes	• Ionic compounds • Molecular compounds that are acids and bases
• **Strong electrolytes**	• Ionic compounds • Strong acids • Strong bases
• **Weak electrolytes**	• Weak acids • Weak bases

Appendix 4 lists the most common strong acids and strong bases.

A conductivity test can help determine the type of substance we are working with.

Conductivity Test[2]:

When a conductivity probe is placed in a solution that contains ions, and thus can conduct electricity, an electrical circuit is completed across the electrodes that are located on either side of the hole near the bottom of the sensor body. This results in a conductivity value that can be read by the detector. The unit of conductivity used in this experiment is microsiemens per centimeter, μS/cm. 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 result in high conductivity values. Weak electrolytes have a low conductivity because they only partially dissociate or ionize producing a lower number of ions. Non-electrolytes have no conductivity.

Based on the <u>concentrations</u> used in this experiment and the <u>instrumentation</u> used, strong electrolytes will exhibit conductivities above 10,000 μS/cm, weak electrolytes will exhibit conductivities between 200 ~ 6000 μS/cm and nonelectrolytes will exhibit conductivities of less than 200 μS/cm. The reason the conductivity of nonelectrolytes may differ from 0 μS/cm is due to impurities (for example, as we breathe, carbon dioxide dissolves in water reacting to form carbonic acid, which is a weak electrolyte, $CO_2(g) + H_2O(g) \rightleftharpoons H_2CO_3(aq)$) and errors/limitations associated with all instrumentation.

pH Test:

The pH will be measured using pH paper.

Chemical Tests:

You will perform several tests on each known solution to determine if they react or not with the test reagent. Some **evidence that a chemical reaction occurs** include:

- Gas evolution. Bubbling or "fizzing" is observed. The gas quickly leaves the solution, so observe carefully when adding the test reagent. Sometimes the gas has a distinctive odor.
- Heat exchange. If the container feels warmer to the touch after the reaction, the reaction released heat (exothermic); if the container feels cooler to the touch, the reaction absorbed heat (endothermic).
- Color change. Sometimes a permanent color change is evidence of a reaction. Do not confuse this with a physical change such as dilution. (For example, a little more water added to a blue solution will make it look lighter because it was diluted, which is a physical change; a completely different color or a change in hue – sky blue to royal blue, for example – might mean that a chemical reaction occurred.)
- A change in pH of at least 2 or more pH units usually indicates a chemical change.

- Formation (or disappearance) of a precipitate. (Sometimes small solid particles stay suspended in the solution rather than precipitating to the bottom. We refer to this as cloudy.) If you cannot see through the solution, a solid (precipitate or cloudy) has been formed. Appendix 2 in conjunction with Appendix 3 can help you determine the chemical formula of the solid formed.

Since the unknown solution is one of the 6 solutions that will be investigated through chemical tests, comparison of results obtained from the chemical tests, along with pH and conductivity values, will allow for proper identification of the unknown solution.

Techniques

- Technique 1: Cleaning glassware
- Technique 11: Disposing chemical waste
- Technique 12: Using pH paper
- Technique 19: Using the LabQuest data collector with conductivity probe

List of Chemicals

- 0.50 M acetic acid ($HC_2H_3O_2$)
- 0.50 M hydrochloric acid (HCl)
- 0.50 M glucose ($C_6H_{12}O_6$)
- 50 % isopropyl alcohol (C_3H_8O)
- 0.50 M magnesium sulfate ($MgSO_4$)
- 0.50 M aluminum chloride ($AlCl_3$)
- 0.2 M silver nitrate ($AgNO_3$)
- 0.2 M sodium carbonate (Na_2CO_3)
- 3 M ammonium hydroxide (NH_4OH)
- 1,000 µS NaCl standard solution
- Benedict's Reagent
- chromic acid (keep and use in hood)

List of Equipment and Glassware

- eight 18 mm x 150 mm test tubes
- two 13 mm x 100 mm test tubes
- one test-tube rack
- two beakers for Waste
- one 250-mL beaker
- LabQuest Data Collector
- one conductivity probe
- instructions sheet for LabQuest Data Collector with conductivity probe
- pH paper
- one stirring rod
- one thermometer
- one test tube holder
- four disposable pipets
- one watch glass
- one 24-well plate
- box of Kimwipes
- utility clamp (two pieces)
- ring stand

Experimental Procedure

Part A: Collecting the Known Solutions and DI Water

1. Obtain eight 18 x 150 mm test tubes, a test-tube rack, and one beaker to use as waste container.
2. Clean and rinse the test tubes with deionized (DI) water. Shake out excess water and dry the outside of the test tubes (a few drops of water left inside will have a negligible effect in this experiment). Label them as follows:
    1. $HC_2H_3O_2$
    2. HCl
    3. $C_6H_{12}O_6$
    4. C_3H_8O
    5. $MgSO_4$
    6. $AlCl_3$
    7. H_2O
    8. Unknown

> *GOLDEN LAB RULE:*
> Be frugal: take only as much as needed. Solutions must never be returned to stock bottles.

3. Obtain a sample of the unknown solution located on the professor's lab bench or other designated area. Record its number in the designated area in the title of Data Table 1 <u>and</u> in the designated area below Data Table 3.
4. Half-fill each test tube with the corresponding solution, all of which are 0.50 M concentration, except for isopropyl alcohol (C_3H_8O) which is 50 %. Add deionized water in test tube 7. Since the solvent for known solutions 1-6 and 8 is deionized (DI) water, it will be useful to measure the conductivity and pH of deionized water. Results different from DI water will then clearly belong to the compound dissolved in it.

Part B: Determination of the Conductivity of the Known Solutions and the Unknown Solution

1. Record the conductivity of the six known solutions, deionized water, and your unknown in Experimental Data Table 1.
2. Obtain a LabQuest Data Collector, conductivity probe, a 1,000 µS NaCl standard solution, and instructions sheet.
3. Set up and calibrate the LabQuest Data Collector with the conductivity probe following the instructions.

Technique 19

4. Carefully hold the conductivity probe in the test tube containing DI water (#7). Make sure that the opening near the bottom of the probe is submerged in the DI water. Be careful that the test tube does not overflow. Swirl the probe to remove any trapped air bubbles.
5. Record the conductivity, in µS/cm.
6. Remove probe, rinse into the waste beaker, and dry.
7. Measure the conductivity of the 6 known solutions and the unknown following steps B4 – B6.

    Note 1: *The readings will normally fluctuate quite a bit. Typically, wait about 30 seconds and then record the reading. Try to read the conductivity to the nearest 10, but for conductivities greater than 1000 you may not be able to do any better than to record it to the nearest 100.*

    Note 2: *Acids have unusually high conductivity values. Reasons go beyond the scope of this experiment. If you are curious, explanations are offered by Jeffery et al.[3] and Atkins.[4]*

> *GOLDEN LAB RULE:*
> Prevent messes: hold the probe above the test tube so that drops fall into the test tube.

Part C: Determination of the pH of the Known Solutions and the Unknown Solution

1. Record the pH of the six known solutions, the unknown and deionized water in Experimental Data Table 1.
2. Obtain pH paper and a clean dry stirring rod.
3. Remove a strip of pH paper about 3 inches long. Place the strip on a clean dry watch glass or a paper towel.
4. Dip the stirring rod into the test tube containing DI water (#7); then touch the pH paper with it (near the left edge).

Technique 12

5. Immediately compare the color on the center of the wet spot with the key on the casing of the pH paper. If the color looks like it is between two adjacent colors, estimate it to the first decimal place (for example, if it looks like it is between 3 and 4, estimate it as 3.5).
6. Record the pH.
7. Using your wash bottle, rinse the stirring rod over waste beaker and dry it with a paper towel.
8. Repeat steps C4 to C7 until you have measured the pH of the 6 known solutions and the unknown using the same strip. If you run out of pH paper cut another small strip.
9. Dispose of the pH paper in the regular trash can.

Part D: Precipitation and Reactivity Tests

1. Obtain a tray containing the following four test reagents: 0.2 M $AgNO_3$ (caution – can stain skin and clothes black, causes no harm), 0.2 M Na_2CO_3, 3 M NH_4OH (caution – caustic, keep away from skin and eyes), and Benedict's Reagent. Set aside for now.
2. Record the observations for the glucose and isopropyl alcohol tests (step 3 below) in Experimental Data table 2.
3. Tests for glucose and isopropyl alcohol:
   Chromic acid tests for the presence of certain alcohols.[5] Benedict's reagent tests for the presence of certain sugars and alcohols.[6] Use these two tests on known solutions of glucose and isopropyl alcohol to see what a positive test looks like.
   a. Obtain two 13 mm x 100 mm test tubes. Label one as $C_6H_{12}O_6$ (B) or 3B. Label the other as C_3H_8O (B) or 4B.
   b. Transfer a portion of the glucose solution (test tube #3) into the test tube labeled $C_6H_{12}O_6$ (B) or 3B (see Figure 2) until it is approximately half-full.
   c. Transfer a portion of the isopropyl alcohol solution (from test tube #4) into the test tube labeled C_3H_8O (B) or 4B (see Figure 2) until the small test tube is approximately half-full.

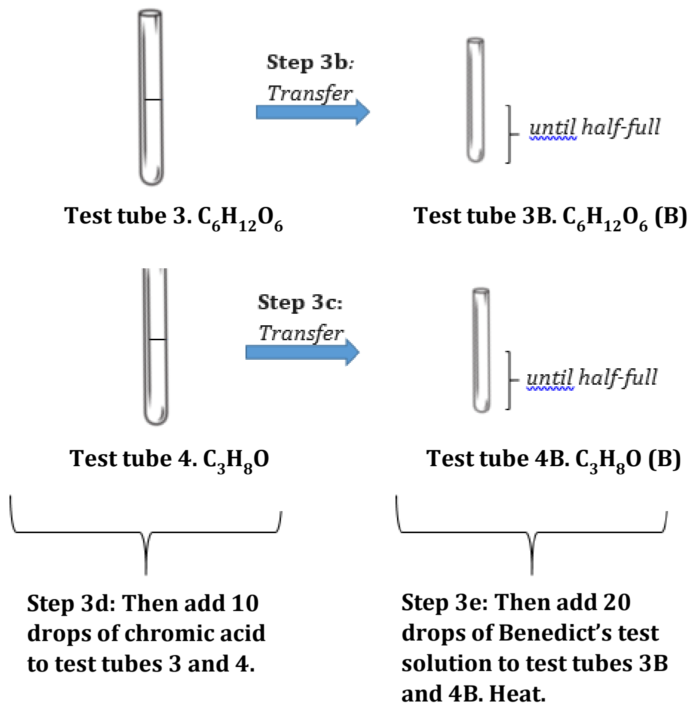

Figure 2. Tests for glucose and isopropyl alcohol.

d. Chromic acid test (chromic acid is in the hood, take larger test tubes #3 & #4 to the hood):

   i. Notice the color of the chromic acid. Add 10 drops of chromic acid to test tubes containing $C_6H_{12}O_6$ and C_3H_8O (#3 and #4 – the two taller test tubes; see Fig. 2). [Chromic acid is in the hood, take these two test tubes and place them in the test tube rack in the hood, carefully add the chromic acid (caution – caustic, keep away from skin and eyes, use gloves)].

   ii. A change in the color of chromic acid is evidence of a chemical reaction. Record observations.

GOLDEN LAB RULE:
Prevent contamination: hold coin stoppers between your fingers with the tip pointing downward while using the reagent.

e. Benedict's reagent test:

   i. Set up a hot water bath as follows: <u>half-fill</u> a 250-mL beaker with DI water. Place a thermometer in the beaker. Heat the water on a hot plate until the thermometer registers a temperature between 60-70 ˚C.

   ii. Add 20 drops of Benedict's test solution to test tubes containing $C_6H_{12}O_6$ (B) and C_3H_8O (B) (3B and 4B – the two shorter test tubes; see Fig. 2).

GOLDEN LAB RULE:
The temperature displayed on the hot plate is not the temperature (T) of the water. Measure T_{water} with thermometer.

iii. Once the water bath reaches the targeted temperature range, turn off the hot plate and place test tubes 3B and 4B in the water bath for about 5 minutes.

iv. Using a test tube holder, remove these test tubes from bath. Record observations.

f. Discard the contents of the four test tubes containing glucose and isopropyl alcohol solutions in the Organic Waste Container located in the hood.

4. Tests for ionic compounds and acids:
You will test for reactivity of the known solutions remaining (solutions #1, 2, 5, 6) with the following three test reagents:

- 0.2 M $AgNO_3$
- 0.2 M Na_2CO_3
- 3 M NH_4OH

Record your observations for this section in Experimental Data table 3.

a. Obtain 3 disposable pipets, and one 24-well plate. Wash the well plate and rinse it with three small portions of DI water; shake excess water over the sink (it is not necessary to dry it). Place a sheet of paper or marking tape above and next to the well plate and write the names or numbers of the solutions and the reagents. You can use a setup like the one shown in Figure 3.

Note 4: *Several reactions produce white solids (observed as precipitates or cloudy solutions). It is easier to see them if the well plate is on the black tabletop instead of on a white sheet of paper.*

b. Add 10 drops of acetic acid (test tube #1) to three wells in the first "row" using a disposable pipet.

i. Add 10 drops of 0.2 M $AgNO_3$ to the first well containing acetic acid. (Be careful to only add drops to the desired well so that you do not cross-contaminate.) Record observations.

ii. Add 10 drops of 0.2 M Na_2CO_3 to the second well containing acetic acid. Record observations.

iii. Add 10 drops of 3 M NH_4OH to the third well containing acetic acid. Record observations.

iv. Mix each well with glass rod, measure and record the solution's pH. Compare values to the pH of the acetic acid measured previously.

c. Add 10 drops of hydrochloric acid (test tube #2) to three wells in the second "row" using a disposable pipet.

- Repeat steps Part 4.b. i-iv above, this time with hydrochloric acid instead of acetic acid.

d. Add 10 drops of magnesium sulfate (test tube #5) to three wells in the third "row" using a disposable pipet.

- Repeat steps Part 4.b. i-iv above, this time with magnesium sulfate instead of acetic acid.

e. Add 10 drops of aluminum chloride (test tube #6) to three wells in the fourth "row" using a disposable pipet.

- Repeat steps Part 4.b. i-iv above, this time with aluminum chloride instead of acetic acid.

f. Do not empty out the well plate yet. You might use it in Part E.

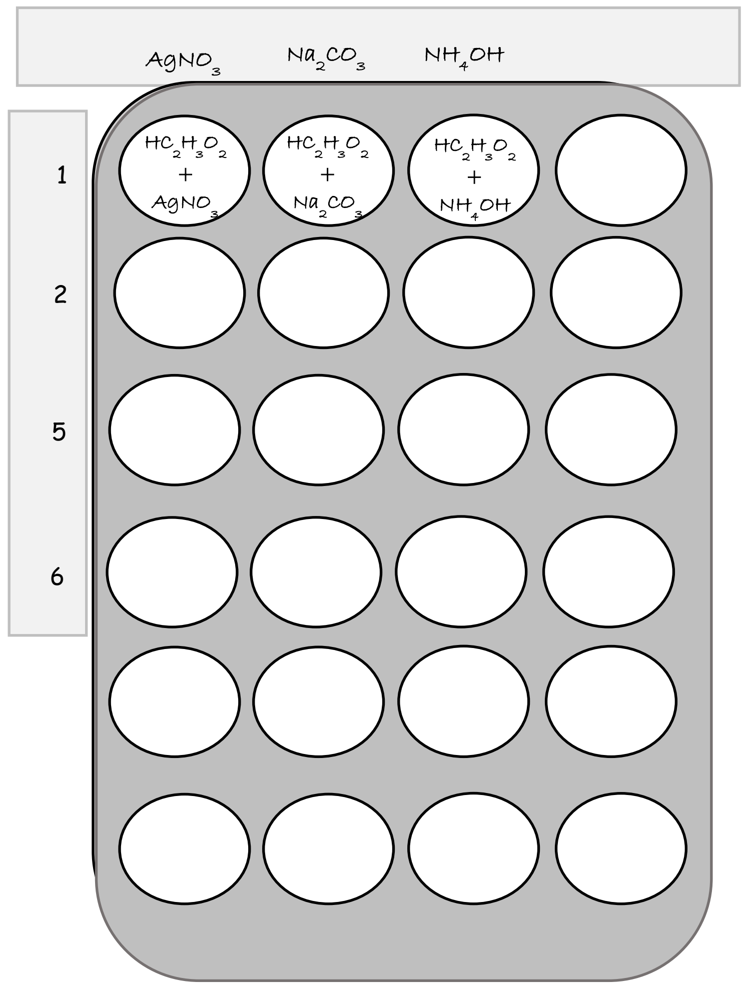

Figure 3. *Setup for reactivity tests using a 24-well plate. Chemicals listed on top border are the test reagents; the numbers on left side are the known solutions.*

Part E: Determination of the Identity of the Unknown Solution

1. Record results of this section in the designated area below Table 3.
2. Compare the values of conductivity and pH for the unknown solution with those of the six known solutions that you recorded in Data Table 1. What is(are) the possible identity(ies) of your unknown?
3. Decide which tests done on the known solutions you want to repeat, this time on the unknown. Record the information in an organized manner.
4. Based on the comparison of the results from the known solutions and the unknown solution determine and report the identity of the unknown solution.

Clean up/Disposal

- Discard the known solutions left in test tubes 1, 2, 5, and 6 containing acids and ionic compounds in the "Ionic/Acid Waste" container located in the hood.
- Discard mixtures in the 24-well plate in the "Ionic/Acid Waste" container in the hood.
- Discard the isopropyl alcohol (test tubes 3 and 3B) and glucose (test tubes 4 and 4B) in the "Organic Waste" container.
- Discard the unknown solution based on its identity, in the correct waste container as stated above.
- Discard the DI water down the sink drain.
- Discard disposable droppers in garbage can (first rinse them with water, transfer this wastewater into the "Ionic/Acid Waste" container located in the hood).
- Wash and dry the outside of all glassware, rinse inside with three small portions of DI water. Return to original location.

Technique

Pre-lab

1. Classify the 6 known solutions as ionic compounds, molecular compounds, or acids.
2. A solution of 1.2 M chlorous acid, $HClO_2$, was found to have a conductivity of 2030 µS/cm. Classify $HClO_2$ as a strong or weak electrolyte.
3. Using the solubility rules found in Appendix 3, organize the following compounds into two groups, water soluble and water insoluble: $Ba(NO_3)_2$, $CaSO_4$, $CoCO_3$, NH_4Br, $Sr(OH)_2$, $Na_2Cr_2O_7$, $Cu_3(PO_4)_2$, Fe_2O_3.
4. Solid sodium sulfate, Na_2SO_4, is water soluble. Write an equation showing how it dissociates in water.
5. A solution of iron(III) nitrate, $Fe(NO_3)_3$, was mixed with a solution of potassium carbonate, K_2CO_3. A precipitate was formed. What is the chemical formula of the precipitate? (See Appendix 2 and Appendix 3.)

Post-lab

The laboratory report should include the following items:

1. All data tables.

2. For the two acids included in the known solutions in Data Table 1:
    a. Classify each as a strong acid or weak acid based on your results for the conductivity test.
    b. Write an equation for the ionization of these two acids. Include phases.

3. Part D step 4 "Tests for ionic compounds and acids" involved mixing some of the known solutions with three test reagents. You recorded these results in Data Table 3. Six of these reactions produced solids (which are observed as cloudy or precipitates). Write the chemical formula for the 6 solids produced. Report these results in the following manner:

Solids Formed from the Reaction of Known Solutions with Test Reagents

Chemical formula of Known Solution*	Chemical formula of Test Reagent**	Chemical formula of Solid Formed

* The known solutions used were acetic acid, hydrochloric acid, magnesium sulfate, and aluminum chloride.

** The test reagents used were silver nitrate, sodium carbonate and ammonium hydroxide.

Only include the information for the six reactions that formed solids.

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VALENCIA COLLEGE

Experiment 3:
Electrolytes and Nonelectrolytes
Experimental Data and Calculations

Name: ____ **Date:** ____________________

Lab Partner: ____ **Section:** __________

Data Table 1. Conductivity and pH of the Known Solutions and Unknown Number __________

Known Solutions	Conductivity ( )	pH
1) 0.50 M acetic acid ($HC_2H_3O_2$)		
2) 0.50 M hydrochloric acid (HCl)		
3) 0.50 M glucose ($C_6H_{12}O_6$)		
4) 50 % isopropyl alcohol (C_3H_8O)		
5) 0.50 M magnesium sulfate ($MgSO_4$)		
6) 0.50 M aluminum chloride ($AlCl_3$)		
7) Deionized water (H_2O)		
8) Unknown		

Data Table 2: Tests Results for Glucose and Isopropyl Alcohol Mixed With Several Test Reagents

Known Solutions	Observations Upon Mixing	
	Chromic acid	Benedict's reagent
3) 0.50 M glucose ($C_6H_{12}O_6$)		
4) 50 % isopropyl alcohol (C_3H_8O)		

Name: ______________________________

Data Table 3: Tests Results for Ionic Compounds and Acids Mixed with Several Test Reagents

Number and Identity Known Solutions	**Observations Upon Mixing**		
	0.2 M $AgNO_3$	**0.2 M Na_2CO_3**	**3 M NH_4OH**
1) 0.50 M acetic acid ($HC_2H_3O_2$)			
2) 0.50 M hydrochloric acid (HCl)			
5) 0.50 M magnesium sulfate ($MgSO_4$)			
6) 0.50 M aluminum chloride ($AlCl_3$)			

Analysis of Unknown Solution: Tests, Observations and Results

Unknown Solution Number ____________

Identity of Unknown Solution ______________