

BOTTLES WITHOUT LABELS: STUDIES OF CHEMICAL REACTIONS

MATERIALS: Eight 50 mL beakers, distilled water bottle, one 100 mL beaker, conductivity meter, pH paper (A/B/N), stirring rod, AgNO₃ in dropper bottle. CuSO₄ in dropper bottle, 125 mL Erlenmeyer flask, 25 mL pipet, pipet bulb, phenolphthalein, 50 mL buret, buret funnel.

PURPOSE: The purpose of this experiment is to identify various solutions based on their properties and study chemical reactions.

PRE-LAB: Before lab, complete the Exp. 5F Pre-Lab Assignment as directed by your instructor. Bring your pre-lab, your safety goggles, and this handout with you to lab.

LEARNING OBJECTIVES: By the end of this experiment, the student should be able to demonstrate the following proficiencies:

1. Understand how pH and conductivity can be used to identify a substance in a solution.
2. Perform a precipitation reaction and write its net ionic equation.
3. Perform an acid-base titration and determine the concentration of the analyte.
4. Understand what happens when substances are added to water.

DISCUSSION:

Chemical reactions involve transformations of chemical substances into one or more new substances. Chemical bonds are broken and new bonds are formed during chemical reactions. Chemical changes are a result of chemical reactions. In general chemistry, you will be studying various types of chemical reactions, such as precipitation, acid-base, and redox reactions. A precipitation reaction results in the formation of an insoluble precipitate, generally from the exchange of parts between two reactants (double-displacement reaction). An acid-base reaction is a neutralization reaction involving a proton-transfer process. In general, acid-base reactions produce water and a salt. A redox reaction is an electron-transfer reaction where changes in oxidation states occur (to be studied in SC112).

Aqueous solutions can be described by a number of properties. Color, density, conductivity, and pH are a few examples of properties that can be used to characterize solutions. In this lab, you will use acidity and conductivity to identify unknown solutions from a list of possibilities. pH is a measure of the acidity of a solution. pH values less than 7 indicate an acidic solution while pH values greater than 7 are basic solutions. A pH of 7 is a neutral solution (at 25°C).

Electrical conductivity is a measure of a substance's ability to conduct an electrical current. Solutions containing a strong electrolyte (many ions in solution) conduct electrical current well. Solutions containing weak electrolytes (few ions in solution) are weak conductors of electricity. Nonelectrolytes do not conduct electricity. In lab, you will measure the conductivity of various solutions and determine whether the solution contains a strong, weak, or non-electrolyte.

PROCEDURE:

Demonstration: Your instructor will demonstrate how to use the 25 mL volumetric pipet. When properly used, a 25 mL pipet will deliver **25.00 mL** (4 significant figures). It is used when an accurate volume is needed.

Part A: Identifying the Unknown Solutions

In lab, you will find bottles labeled A, B, C, and D. These aqueous solutions have "lost" their original labels so you must identify the solutions to proceed with the experiment. Because you don't know exactly what the substances are, handle them with care. Make sure to avoid cross-contamination of the solutions. Do not pour solutions back into the original containers. Read the procedure carefully, using distilled water where specified.

1. Rinse six 50 mL beakers with distilled water. There is no need to dry them completely. Distilled water, not tap water, must be used in Part A.
2. Place about 30 mL of each unknown solution (A, B, C, D) into its own 50 mL beaker. Place about 30 mL of distilled water into one additional beaker, and 30 mL of tap water into another beaker. Label each beaker.
3. Determine the conductivity of each solution using the conductivity meter (be careful with these meters).
 - a. Turn on the conductivity meter by switching the on/off switch.
 - b. Into a waste beaker, rinse the electrodes with distilled water from a squirt bottle. Only rinse the electrodes (2 prongs), not the battery or electronics. Make sure the electrodes do not touch each other or the circuit will be shorted.

- Place the electrode prongs into the first solution (Solution A). You may need to tip the beaker slightly to make sure the 2 electrodes contact the solution. Poor contact leads to faulty signals.
- Use the code below to determine the conductivity of the solution (none, medium, high). Basically, the brighter the lights, the more conductive the solution. High conductivity indicates a strong electrolyte solution. Turning off the lights in your hood may help you see the colored lights better.
- Rinse the electrodes, gently dry with a paper towel, and determine the conductivity of the other solutions.
- After the last solution, rinse the electrodes with distilled water and gently dry the electrodes with a paper towel.
- Turn OFF** the conductivity meter.

Red LED	Green LED	Conductivity	Designation
Off	Off	None	Non-electrolyte
Dim	Off	Low	
Medium	Off to Low	Medium	Weak electrolyte
Bright	Medium to Bright	High	Strong electrolyte



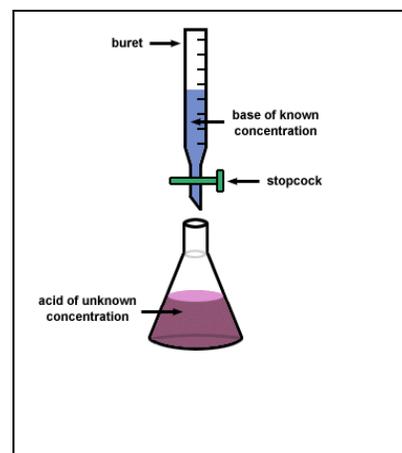
- Determine the acid base properties of the solutions by utilizing pH paper.
 - Remove a small strip of pH paper from the canister.
 - Dip a clean stirring rod into the solution and add a small drop to the pH paper.
 - Compare the color change to the legend on the canister to determine if the solution was acidic, basic, or neutral. The color changes may be slight. If no color change occurs, just darkening due to the liquid, the solution is neutral. Any reddish color is acidic. Blue or green is basic. Be aware that you should **ONLY** identify the substance as acidic or basic if it is **MORE** acidic or basic than water.
 - Repeat with the other solutions, rinsing and drying the stirring rod between solutions.
- Based on your data, determine the identities of the 4 unknowns from the list of possible solutions. Before proceeding, *check with your instructor to find out if you were correct.*
- Save your solutions** since you'll need some of them for Parts B and C.

Part B: Precipitation Reactions

- Split your Solution A (from Part A) roughly in half between two beakers.
- To one beaker containing Solution A, add a few drops of AgNO_3 solution. Record any observations.
- To the other beaker containing Solution A, add a few drops of CuSO_4 solution. Record any observations.
- Dispose of these solutions in the waste bucket in the instructor's hood.

Part C: Acid-Base Reactions

- You will titrate the acidic and basic solutions from Part A. Which solution was acidic? Which was basic?
- Using a 25 mL pipet, add 25.00 mL of your *acidic* solution from Part A to an Erlenmeyer flask. This is the volume of acid that you are titrating.
- Add 2-3 drops of phenolphthalein indicator to the flask.
- Fill your buret with your *basic* solution from Part A. You should have at least 40 mL in your buret (filled to ~ 10 mL mark). Obtain more if needed (it does not need to be filled to 0.00 mL). This basic solution has a molarity of ~0.1000 M, however, the actual bottle will have the specific value.
- Record the initial buret reading (using the correct number of significant figures).
- Titrate the solution until there is a permanent, pink color change. The fainter the pink (permanent pink), the better the titration. The color change indicates the equivalence point of the titration.
- Record your final buret reading (using the correct number of significant figures).



Clean-up:

- Part B solutions are disposed in the instructor's hood. Other solutions can be washed into the sink. Store cleaned burets upside down in a buret clamp with the stopcock open.
- Rinse all glassware. Use distilled water to rinse the 50 mL beakers. Start the calculations.

Name _____

Section _____

Partner _____

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DATA AND ANALYSIS:**Part A: Identifying the Unknown Solutions**

Solution	Conductivity level	Strong, Weak, or Non-Electrolyte?	Acidic, Basic, or Neutral?	Identity*
A				
B				
C				
D				
Distilled water				Distilled Water
Tap Water				Tap Water

Possible Solutions*HCl, NaOH, CH₃COOH, NH₃, NaCl, C₁₂H₂₂O₁₁

Instructor's Initials _____

Part B: Precipitation Reactions

Solution A = _____ (see above)

Solution A mixed with:	Observations	Did a chemical reaction occur?	Did a precipitate form?	IF a precipitate formed, give its chemical formula <u>and</u> its name.
AgNO ₃				
CuSO ₄				

For the chemical reaction above that produced a precipitate:

- Write the balanced molecular equation for the reaction. (You should know what Solution A is.) Include the states for each species (s, l, g, aq).
- Write the complete ionic equation. Include the states for each species (s, l, g, aq).
- Write the net ionic equation. Include the states for each species (s, l, g, aq).
- What were the spectator ions in this reaction? _____

Part C: Acid-Base Reactions

Record with units and proper significant figures.

Volume of acid titrated	
Initial buret reading	
Final buret reading	
Volume of 0.1000 M base added	

1. Based on your identifications from Part A, write the balanced molecular equation for the acid-base reaction that is occurring during this titration. Include the states for each species (s, l, g, aq).
2. Based on the titration data, determine the moles of base added during the titration. M = Molarity = moles/L
3. Based on the stoichiometry of the reaction, how many moles of acid were titrated (to equivalence point)?
4. Determine the concentration (in M) of the acid solution titrated. M = Molarity = moles/L
Report with the proper number of significant figures.

QUESTIONS:

1. Identify the following as a strong, weak, or non electrolyte.

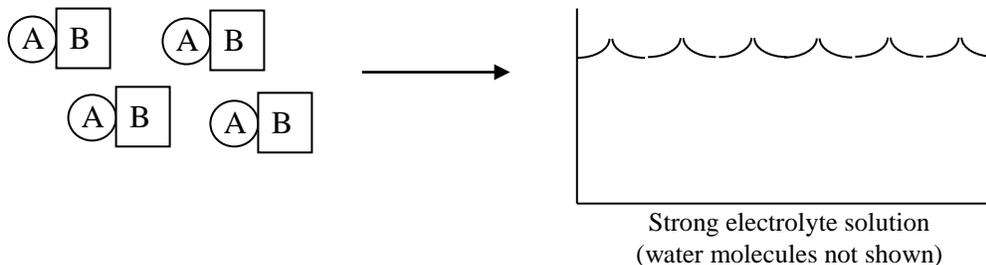
a. HCl (aq)	Strong	Weak	Non-electrolyte
b. KNO ₃ (aq)	Strong	Weak	Non-electrolyte
c. NH ₃ (aq)	Strong	Weak	Non-electrolyte
d. CH ₃ OH (l), methanol	Strong	Weak	Non-electrolyte
e. BaCl ₂ (aq)	Strong	Weak	Non-electrolyte
2. a. What are the products formed in this reaction? Include the states (s, l, g, aq). Balance the reaction.
$$\text{_____ K}_2\text{SO}_4 \text{ (aq)} + \text{_____ BaCl}_2 \text{ (aq)} \rightarrow \text{_____} + \text{_____}$$

b. Write the complete ionic equation for this reaction. Include states.

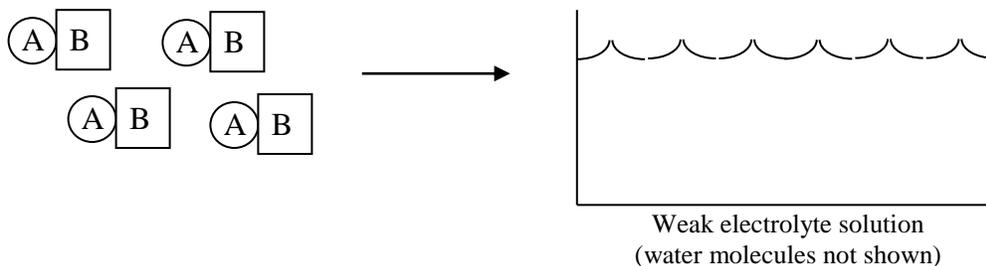
c. Write the balanced, *net ionic* equation for this reaction. Include states. Name the precipitate produced.

3. Assume you have a compound, AB, and that it can be represented by:  When AB is placed in water, it dissolves completely. (Note that 'dissolving' and 'dissociating' are different processes.)

- a. Assume AB is a **strong** electrolyte and thus conducts electricity when dissolved in water. If 4 molecules of AB are added to water, draw a picture that represents what exists in the solution.



- b. Assume AB is a **weak** electrolyte. If 4 molecules of AB are added to water, draw a picture that represents what exists in the solution.



4. Identify the following as a strong acid, weak acid, strong base, or weak base:

- | | | | | |
|-----------------------------|-------------|-----------|-------------|-----------|
| a. HBr (aq) | strong acid | weak acid | strong base | weak base |
| b. NH ₃ (aq) | strong acid | weak acid | strong base | weak base |
| c. Ba(OH) ₂ (aq) | strong acid | weak acid | strong base | weak base |
| d. HNO ₃ (aq) | strong acid | weak acid | strong base | weak base |
| e. HF (aq) | strong acid | weak acid | strong base | weak base |

5. a. Write the *balanced*, molecular equation for the reaction between nitric acid and barium hydroxide.

b. What is the mole ratio between nitric acid and barium hydroxide? $\frac{\quad}{\text{nitric acid}}$: $\frac{\quad}{\text{barium hydroxide}}$

c. If 25.00 mL of 0.1000 M nitric acid is titrated with 0.1000 M barium hydroxide, how many milliliters (mL) of barium hydroxide would it take to reach the equivalence point of this titration?

6. What happens when substances are added to water?¹

MODEL

Based on what you know, you are to develop an “Model” which describes your understanding of what happens to substances when they are added to water. For your initial model, discuss salt (NaCl) and sugar (C₁₂H₂₂O₁₁ or sucrose), two solids that can be found in any kitchen cupboard. Describe what you expect to *observe* (see, hear, feel, smell) before and after you have added salt (or sugar) to water. This is your *macroscopic model*. Then, explain what you think the molecules, atoms, and/or ions are doing that results in your observations; this is your *molecular-level model* (what you *can't see*). In your observations distinguish between the terms ‘dissolve’ and ‘dissociate’. A picture could be used to help in your explanation.

a. **MACROSCOPIC model** (what you would *observe*) – use words and/or pictures to explain, label

NaCl and water		C ₁₂ H ₂₂ O ₁₁ and water	
Before mixing	After mixing	Before mixing	After mixing

b. **MOLECULAR-LEVEL model** (what you expect the molecules, atoms, and/or ions are doing in solution, what you *can't see*) - use words and/or pictures to explain, label clearly

NaCl in water AFTER mixing	C ₁₂ H ₂₂ O ₁₁ in water AFTER mixing

¹adapted from A.C., Mattox, B.A. Reisner, S. Anthony, N.J. Boldt, D. Rickey, and M.A. Teichert, “What happens when substances are added to water?” lab handout (MORE).

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 PRE-LAB EXERCISES

Complete this page prior to attending lab.

1. Give the chemical formulas for the following and determine if they are strong, weak, or non-electrolytes, and if they are soluble or insoluble in water.

	Chemical formula	Strong, weak, or Non-electrolyte?	Soluble or insoluble?
Lead(II) nitrate			
Potassium chloride			

2. When lead(II) nitrate and potassium chloride react, what are the 2 products that form?

	Chemical formula	Chemical name	Soluble or insoluble?
Product 1			
Product 2			

3. a. Write the *balanced, molecular* equation for the reaction that occurs between lead(II) nitrate and potassium chloride. Include the states for each species (s, l, g, or aq).

- b. Write the complete ionic equation for this reaction. Include the states for each species (s, l, g, aq).

- c. Write the net ionic equation for this reaction. Include the states for each species (s, l, g, aq).

4. What is the common name for $C_{12}H_{22}O_{11}$? _____

What is the chemical name for CH_3COOH ? _____

5. Identify the following chemical reactions as either a precipitation or acid-base reaction.

- | | | |
|---|---------------|-----------|
| a. $HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(l)$ | Precipitation | Acid/Base |
| b. $3Ca^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$ | Precipitation | Acid/Base |
| c. $2AgNO_3(aq) + Na_2SO_4(aq) \rightarrow 2NaNO_3(aq) + Ag_2SO_4(s)$ | Precipitation | Acid/Base |
| d. $Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2CO_3(aq)$ | Precipitation | Acid/Base |