

# Identifying an unknown contaminant using qualitative and quantitative tests



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## Identifying an Unknown Contaminant Using Qualitative and Quantitative Tests

### INTRODUCTION

#### Background:

Knowing how to identify chemicals is important in a day-to-day setting because it can be applied in multiple situations. A common situation that should be important to the average person would be on a crime scene investigation. More specifically, it can be used to in the study of forensics. Being able to identify chemicals would be helpful when it comes to drug use or any other illegal use of substances. If chemicals can be identified after they have been dissolved in something, then it would be harder for someone to destroy evidence. In the conducted experiment, common contaminants were used that are commonly found in water samples, but it could be applied to almost any chemical by solubility, flame test, pH test, conductivity, precipitation, and titration. Conducting these tests in a laboratory is important because it is a more controlled environment than doing it out on the field somewhere. Then a test can be properly carried out and the person who committed wrongdoings can be punished accordingly.

#### Theory:

In this experiment, many tests were carried out including solubility, conductivity, flame test, pH test, precipitation, and titration and each of the tests are classified as qualitative or quantitative. A qualitative analysis is defined as collecting characteristics of an unknown about the reactivity to

identify the chemical. Qualitative analysis is preliminary because the quantitative analysis confirms the qualitative. Some examples of quantitative analysis used are solubility, titration, pH test, flame test, etc. To perform the solubility test, DI water, HCl, NaOH, ethanol, and acetone were used as the solvents. Then known and unknown contaminants were taken to dissolve in the multiple liquids. This way there could be a comparison of what the contaminants dissolved in and what they did not. After the solubility test, there were to be two to four substances that could be the unknown. Then recorded which of the solvents dissolved the solutes. Acid-base titration was performed by first taking a pH test to decide whether the solution is acidic or basic. Then depending on results, a base or acid would be added to the solution with an indicator to determine when the mixture is neutral. The pH test was simply performed by putting a pH meter in the solution and reading what the pH was. This test can help for the acid-base titration because then it would be known what to add to make the solution neutral. The flame test is relatively simple because the unknown and a known are burned to see what color the flame is. The colors were to be recorded and compared between a few chemicals. The precipitation reaction is one of the more difficult tests. It was performed by dissolving the unknown in  $\text{AgNO}_3$  and  $\text{BaCl}_2$ . Then from visual observation it should be possible to see which solution the chemicals dissolved and formed a precipitate. By examining a solubility table, it makes it easier to understand what the precipitate could be. From there the solution needed to be funneled and filtered to get the precipitate by itself and then the precipitate was placed in the oven.

Hypothesis:

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Based on visual observations, the hypothesis was that the unknown was either ammonium chloride, calcium chloride, or sodium oxalate. This hypothesis was reached by the visual cues of the white, powdery texture of the substance.

#### Objectives:

The objective for Week 1 was to perform a solubility and flame test to narrow down the choice of what the unknown could be. The objective of Week 2 was to continue testing to solidify a preliminary answer because it should have been down narrowed down enough. The tests performed during Week 2 were pH levels, titration, conductivity, and precipitation reactions.

#### METHODS

##### Part 1 Methods:

The glassware and other tools used in the experiment were four 250 mL beakers, funnel, glass stirring rod, disposable pipettes, Bunsen burner, wire loop, four test tubes, a well plate, and a magnetic stir plate. The contaminants provided were  $\text{CaCl}_2$ ,  $\text{NaNO}_3$ ,  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{NH}_4\text{Cl}$ ,  $\text{MgSO}_4$ ,  $\text{Ca}(\text{NO}_3)_2$ ,  $\text{CH}_3\text{CO}_2\text{Na}$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{Na}_2\text{C}_2\text{O}_4$ , and  $\text{NaCl}$ .  $\text{HCl}$  was provided as the acid,  $\text{NaOH}$  as the base, acetone, DI water, and ethanol.

##### Solubility Procedure:

1. Get a well plate and label each row and column of which solute and solvent will be in each well
2. Get 5 test tubes for the acetone solubility to be tested in

3. Get DI water, NaOH, HCl, Ethanol, and Acetone in a respective beaker
4. Use a pipette to distribute the solvents into the well plate and test tubes
5. Gather the contaminants being testing and place them in each solvent and stir to test solubility
6. Record results on table of what solute dissolved in which solvent

#### Conductivity Procedure:

1. Dissolve 0. 2 grams of solute into 100 mL of DI water in a beaker
2. Use multimeter to test the conductivity of the solution
3. Record the results and repeat in order to ensure a correct reading

#### pH Test Procedure:

1. Use same solution of 1 gram of solute to 100 mL of water in a beaker
2. Use pH meter to test the acidity or basic levels
3. Record answers on table

#### Flame Test Procedure:

1. Dip wire loop into DI water and pick up some of salt
2. Put wire loop into Bunsen burner flame
3. Record what color the chemical burned

#### Titration Procedure:

1. If solution is acidic, then place a basic solution into the burette to titrate into the acidic solution

2. If solution is basic, then place an acidic solution into the burette to titrate into the basic solution
3. Add pH indicator drops (Phenolphthalein) into beginning solution (will change color when pH is neutral)
4. Slowly add the base or acid into the solution and wait for the solution to change color to pink
5. Record the amount added onto the table
6. Repeat 3 times and take the average

#### Part 2 Methods:

The glassware and other tools used in the experiment are a filter, funnel, oven, 250 mL beaker, waste bucket, watch glass, and scoopula. The chemicals used were  $\text{AgNO}_3$  and  $\text{BaCl}_2$  and the unknown.

#### Gravimetric Analysis/Precipitate Reaction Procedure:

1. Dissolve 1 gram of solute into 250 mL DI water into beaker. Repeat
2. Add 50 mL of  $\text{AgNO}_3$  and 50 mL of  $\text{BaCl}_2$  in respective beakers
3. Mix well
4. Observe visually to see which solution precipitates
5. Take precipitate reaction to funnel with filter paper
6. Run through machine to get precipitate
7. Place precipitate on watch glass and put in oven for 10 minutes
8. Weigh the precipitate and compare to known chemicals

#### Safety:

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 SO<sub>2</sub> eyes, skin, and  
 g/ clothing. Wash  
 4 m hands after  
 CH<sub>3</sub>OH handling. Wear  
 fe 3 gloves and goggles.  
 CO<sub>2</sub> 4. Store safely at room  
 2 temperature  
 Na<sub>2</sub>CO<sub>3</sub>  
 2  
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Ski Ca 1 Be in well ventilated  
 n Cl 1 area. Avoid contact  
 Irri 2 0. with skin, eyes, and  
 ta Na 9 clothing. Wash  
 nt NO 8 hands after  
 3 g/ handling. Wear  
 Na m scrub pants, gloves,  
 2 ol goggles, and lab  
 coat. Keep away

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 xic H 4 6. gloves, goggles and  
 ) 2 0 lab coat. Be in well  
 SO 6 ventilated area.  
 4 g/ Handle carefully and  
 NH m avoid contact with  
 4 ol eyes, skin, and  
 Cl 5 clothing. Store in  
 Ca 3. tight container and  
 at room



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en burning. Wear gloves

Burn and goggles and avoid

er direct contact with  
flame.

Ove Make sure to have heat  
n resistant gloves and  
tongs to get products out  
of the oven. Wear  
goggles.

MgSO<sub>4</sub> Magnesium  
Sulfate

CaCl<sub>2</sub> Calcium Chloride

(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> Ammonium  
Sulfate

CH<sub>3</sub>CO<sub>2</sub>Na Sodium Acetate

Na<sub>2</sub>C<sub>2</sub>O<sub>4</sub> Sodium Oxalate

Ca(NO<sub>3</sub>)<sub>2</sub> Calcium Nitrite

NaNO<sub>3</sub> Sodium Nitrate

Na<sub>2</sub>CO<sub>3</sub> Sodium  
Carbonate

NH<sub>4</sub>Cl      Ammonium  
                  Chloride

RESULTS

Part 1 Results:

Titration was not performed because pH of unknown was neutral

Trial	Acid Volume (mL)	Base Volume (mL)	# of indicator drops	Acid (M) Concentration	Base (M) Concentration
1					
2					
3					
Av.					
Volume					

Salts      Water    HCl    NaOH    Ethanol    Acetone    Flame    Conductivity    pH

						Test		
CaCl <sub>2</sub>	x	x	-	x	x	red	27.8 mS	7
NaNO <sub>3</sub>	x	-	x	-	-	-	-	-
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	x	x	x	-	-	-	-	-
NH <sub>4</sub> Cl	x	x	x	-	x	No color	-	-
MgSO <sub>4</sub>	x	x	x	-	-	-	-	-
Ca(NO <sub>3</sub> ) <sub>2</sub>	x	x	-	x	-	-	-	-
CH <sub>3</sub> CO <sub>2</sub> Na	x	x	x	-	-	-	-	-
Na <sub>2</sub> CO <sub>3</sub>	-	x	-	-	-	-	-	-
Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	-	-	-	-	-	-	-	-
NaCl	x	-	x	-	-	-	-	-

Unknown

x x - x x red 27.7 mS 7

Part 2 Results:

Initial unknown mass	Volume of DI water	Reaction/Precipitate?	Theoretical Yield	Precipitate formed?	Standard deviation/Percent Error
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50 mL

of AgNO<sub>3</sub> 1 gram 250 mL Yes 2.58 g AgCl 1.78 g AgCl 31%

50 mL

of BaCl<sub>2</sub> 1 gram 250 mL No - - -

Initial CaCl <sub>2</sub> mass	Volume of DI water	Reaction/Precipitate?	Theoretical Yield	Precipitate formed?	Standard deviation/Percent Error
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						Percent Error
50 mL of AgNO <sub>3</sub>	1 gram	250 mL	Yes	2.58 g AgCl	1.78 g AgCl	31%

50 mL of BaCl <sub>2</sub>	1 gram	250 mL	No	-	-	-
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Calculations:

- Precipitate Reactions
  - $\text{CaCl}_2 + 2 \text{AgNO}_3 \rightarrow 2 \text{AgCl} + \text{Ca}(\text{NO}_3)_2$
- Molarity/Volume
  - $M_1 V_1 = M_2 V_2$ 
    - Ex.  $(100 \text{ mL})(M_1) = (50 \text{ mL})(3.0 \text{ M}); M_1 = 1.5 \text{ M}$
- Percent Yield
  - $(\text{Actual yield} \div \text{Theoretical Yield}) \times 100 = \_\%$ 
    - Ex.
- Percent Error
  - $[(\text{Absolute value of experimental value} - \text{exact value}) \div \text{exact value}] \times 100 = \_\%$ 
    - Ex.

## DISCUSSION

### Part 1 Discussion:

The experiment was very similar to the theory, but a few tests were not performed because of the unknown that was received. In the experiment, the solubility test was performed first to narrow down the options of solutes. Then using the flame test it already identified the unknown, but to further confirm the chemical in question, pH tests, conductivity tests, and precipitate reactions were done during week 2. The unknown was known to be  $\text{CaCl}_2$  because all the testing of the unknown had almost identical results to  $\text{CaCl}_2$ . In the solubility testing, the only chemical that was the same as the unknown was  $\text{CaCl}_2$ . The performed flame test on another chemical,  $\text{NH}_4\text{Cl}$ , showed that  $\text{CaCl}_2$  produced similar results to the unknown. After the flame test was performed, it was observed that the Calcium chloride burned the same color red as the unknown while Ammonium chloride did not burn any specific color. The rest of the testing consisted of comparing  $\text{CaCl}_2$  to the unknown to make sure everything continued to line up. If the results did not match, then a reevaluation of what the unknown is would need to happen. All of the results lined up so more testing did not need to be done.

### Part 2 Discussion:

The precipitation reaction performed lined up well with the theory. Only one of the reactants produced a precipitate with the unknown. A 300 mL solution was made with a reactant, the solute, and DI water. This was then filtered through a funnel and then the precipitate was able to be collected on the filter paper and transferred to a watch glass for it to be dried in the oven.

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The gravimetric analysis supports the hypothesis partially because it was not certain what the unknown was, but it did confirm it was one of the three possibilities previously stated. The experiment was only partially effective because the percent yield was only 69%. The reaction only made 1.78 grams of AgCl when theoretically it should've made 2.58 grams of AgCl.

#### Sources of Error:

Possible sources of error that could occur in the lab are contaminated glassware, inaccurate measurements, and uncontrollable reactions with the outside factors. Glassware can never be completely clean because of the amount of times that it has been used. It is also hard to tell when it could be clean. As measurements are taken, it is common for people to see different readings on an instrument. Also, electronic tools could be calibrated incorrectly leading to incorrect measurements. Even though the experiment was in a controlled environment there is a possibility for things in the air to react with solutions.

#### Changes to Experiment:

#### Conclusion:

The purpose of the lab was to identify an unknown substance using qualitative and quantitative testing. With the testing performed it was possible to compare known compounds to the unknown to help narrow down and eventually pinpoint what the unknown was. The hypothesis was confirmed that the unknown was either ammonium chloride, sodium oxalate, or calcium chloride. The unknown turned out to be calcium chloride,



therefore solidifying the hypothesis. A variety of data was gained from multiple tests including solubility, flame test, precipitation reactions, pH tests, and conductivity. All evidence collected strongly supported the unknown being  $\text{CaCl}_2$  because all the tests yielded the same result or something very similar to it. The only problem was that the percent error was quite high for the precipitation reaction.

## RESEARCH CONNECTION

### Research Connection:

This article discussed contaminants found in drinking water and the effects of certain contaminants. The article specifically focuses on specific pathogen that has been linked to allergens and infections. Its' focus brings attention to the health risks associated with tainted water sources in public residences. The United States Environmental Protection Agency sets standards of what is safe drinking water for people. Globally, the water safety standards differ slightly. Some countries include fungi in the safety and others believe that fungi are not harmful to humans but just cause an odor. It was found that in the Czech Republic that the water contained 50 individuals/mL. The researchers did answer their question of what was considered safe contaminants in water because they compiled a list of safe vs. unsafe organisms and listed what they contributed to.

## References:

- Ahmed, W.; Beale, D. Fungal Contaminants in Drinking Water Regulation? A Tale of Ecology, Exposure, Purification and Clinical

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*Google Scholar*. <https://www.mdpi.com/1660-4601/14/6/636/html>  
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