The Synthesis and Analysis of Alum

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Abstract
The goal of this lab is to synthesize alum and analyze your sample of alum, along with a stock sample, for the melting point, water of hydration, and percent sulfate. After finding that the theoretical yield of alum was 18.82g, we found that our sample only had a percent yield of 69.14% alum. My sample's average melting point was 92.55°C compared to the theoretical 92.5°C. Water of hydration and percent sulfate led to finding the percent composition of alum. The percent composition was then used to find that the empirical formula of my alum was $K_{\mathbf{4}}Al_{\mathbf{12}}(SO_4)_{27}\bullet 156H_2O$.

Purpose
The objective of this lab is to synthesize a sample of alum and analyze your sample of alum and the stock alum for melting point, water of hydration, and percent sulfate. We are doing this lab because in class we are reviewing how to create an empirical formula from finding masses and moles of compounds.

Materials

Synthesis Materials
- 250mL beaker
- 25mL or 50mL graduated cylinder
- Büchner funnel and filter flask
- Glass stirring rod
- Lab burner, ring stand, ring, wire gauze
- Plastic wrap or Parafilm®
- Fume hood
- Hot plate
- Aluminum foil
- 3M sulfuric acid solution
- 3M potassium hydroxide solution
- Aqueous ethanol solution, 50%
- Ice bath
- Balance

Analysis Materials
Part 1, Melting Temperature Test Materials
- Vernier computer interface
- Computer
- Temperature probe
- Capillary tubes
- 150mL beaker
- Glass stirring rod

- Alum crystals
- Hot plate
- Ring stand, ring, wire gauze
- Utility clamp
- Small rubber band

Part 2, Water of Hydration Test Materials

- Crucible with cover
- Balance
- Lab burner
- Alum crystals
- Ring stand, ring, clay triangle
- Tongs or forceps

Part 3, Percent Sulfate Test Materials

- 250mL beaker
- Balance
- Gooch crucible filter apparatus
- Rubber policeman
- Alum crystals
- 0.20M $SrCl_2$ solution
- Ring stand, ring, wire gauze
- 50mL or 100mL graduated cylinders
- Glass stirring rod

Procedure

Synthesis Procedure

1. Obtain and wear goggles.

2. Obtain a piece of aluminum foil and measure its mass. For best results, you should have about 1.00 g of aluminum. Tear the foil into small pieces and place the pieces in a 250 mL beaker.

3. Set up a Büchner funnel and filter flask so that you are ready to filter the reaction mixture that will be produced in Step 4.

4. Conduct the first part of the synthesis. **CAUTION**: *Potassium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.*
   a. Use a graduated cylinder to measure out 25 mL of 3 M KOH solution.
   b. *Slowly* add the KOH solution to the beaker of aluminum pieces. Notice that the reaction is exothermic. Allow the reaction to proceed until all of the foil is dissolved.
   c. Carefully pour the reaction mixture through your Büchner funnel and filter flask setup, and rinse the filter paper with a small amount of distilled water.

Note: The reaction mixture contains three ions: K^+, $[Al(OH)_4^-]$, and excess OH^-.

d. Rinse the beaker with distilled water, and pour the filtered liquid back into the beaker.

5. Allow the solution to cool to near room temperature. If you are pressed for time, you may cover the beaker with plastic wrap or Parafilm, and store the liquid overnight.

6. Clean the Büchner funnel and filter flask, and prepare it for more filtering that you may need to do in Step 7 or Step 10.

7. Complete the synthesis.

   a. Use a graduated cylinder to measure out 35 mL of 3 M H_2SO_4 solution. **CAUTION**: *The reaction mixture must be cooled to room temperature before proceeding. Handle the H_2SO_4 solution with care. It can cause painful burns if it comes in contact with the skin.*

   b. After the reaction mixture has cooled, slowly add the sulfuric acid solution to the beaker of liquid. Stir the mixture constantly. The reaction is strongly exothermic, so be careful as you stir the mixture. Note that aluminum hydroxide will precipitate initially. It will dissolve as more sulfuric acid is added.

   c. If there is some solid remaining in the beaker after the 35 mL of sulfuric acid has been added, pour the mixture through the Büchner funnel and filter flask to separate the undissolved solid from the mixture.

8. Gently boil your mixture until you have about 50 mL of liquid in the beaker.

9. Cool the beaker of solution. Choose one of the two methods listed below.

   - Allow the solution to cool overnight. In most cases, this gradual cooling forms a good crop of alum crystals.
   - Prepare an ice bath for the 250 mL beaker. Place your beaker of solution, uncovered, in the ice bath. Do not move the ice bath or the beaker. After about fifteen minutes, crystals of alum will appear in the beaker. If there are no crystals after fifteen minutes, scrape the bottom of the beaker with a glass stirring rod to create a rough spot for crystal growth. You may also heat the solution to evaporate more water and cool the solution again.

10. Collect your alum crystals by pouring them onto the Büchner funnel and filter-flask setup. Use vacuum filtration to wash the crystals on the filter paper with 50 mL of an aqueous ethanol solution (50%). The crystals will not dissolve in this solution.

11. Remove the filter and crystals from the Büchner funnel and allow the crystals to dry at room temperature. Measure and record the mass of your sample of alum. Store the crystals for further analysis.

Analysis Procedure

Part 1, Determine the Melting Temperature of Alum

1. Obtain and wear goggles.

2. Connect a Temperature Probe to Channel 1 of the Vernier computer interface. Connect the interface to the computer with the proper cable.

3. Start the Logger *Pro* program on your computer. Open the file "15b Alum" from the *Advanced Chemistry with Vernier* folder.

4. Use a mortar and pestle to pulverize about 0.5 g of dry alum and place it in a small pile in the mortar. Push the open end of a capillary tube into the pile of the alum powder. Pack alum into the capillary tube to a depth of about 1 cm by tapping the tube lightly on the table top.

5. Use a rubber band to fasten the capillary tube to the Temperature Probe. The tip of the tube should be even with the tip of the probe. Use a utility clamp to connect the Temperature Probe to a ring stand. If necessary, place the probe in a split stopper or a cork to secure it in the clamp (see Figure 1).

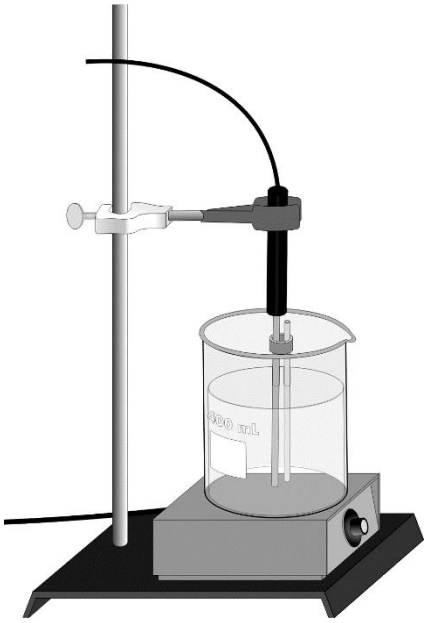


Figure 1

6. Prepare a water bath to be heated by a hot plate. Your instructor may also direct you to use a Thiele tube. If you do not use a Thiele tube, stir the water bath throughout the testing to maintain a constant bath temperature.

7. Click Collect to begin data collection. Immerse the capillary tube and Temperature Probe in the water bath. Warm the alum sample at a gradual rate so that you can precisely determine the melting temperature. The white powder will become clear when it is melting. Observe the temperature readings and record the precise melting temperature when the substance is completely clear.

8. Conduct a second test with a new sample of alum in a new capillary tube.

Part 2, Determine the Water of Hydration of Alum

9. Heat a crucible with cover over a burner flame until it is red hot. Allow the crucible to cool, and then measure the total mass of the crucible and cover. Handle the crucible with tongs or forceps to avoid getting fingerprints on it.

10. Place about 2 g of your alum crystals in the crucible, and then measure the mass of the crucible, cover, and alum. Record this measurement in the data table.

11. Select one of the two drying methods listed below.
    - Set up a ring, ring stand and triangle over a lab burner. Use tongs or forceps to set the crucible at an angle on the triangle and place the cover loosely on the crucible. Use a lab burner to very gently heat the crucible of alum until you can see no vapor escaping from the crucible. It is important that the vapor does not carry any alum with it. After the vapor is gone, heat the crucible more strongly for five minutes, and then cool the crucible.
    - Place the crucible in an oven overnight at 110°C.

12. Measure and record the mass of the crucible, cover, and alum after drying.

13. Reheat the crucible and alum sample for five additional minutes. Cool and measure the mass of the crucible again. If the two masses are the same (or very nearly so), the test is done. If not, repeat the heating and weighing until a constant mass is obtained.

Part 3, Determine the Percent Sulfate of Alum

14. Obtain a clean, dry Gooch crucible and measure its mass. If you must clean the crucible, follow the procedure in Step 15. If not, proceed directly to Step 16. If you are not using a Gooch crucible, then use the finest-grain filter paper available, such as Whatman No. 42. Measure and record the mass of the filter paper.

15. To clean a Gooch crucible, assemble the crucible, Walters adapter, and filter flask. Use suction to draw distilled water through the filter pad. Place the crucible in a beaker and dry it in an oven.

16. Measure the mass of about one gram of your alum sample into a 250 mL beaker. Add about 50 mL of distilled water to the beaker of alum and stir the mixture to dissolve the sample.

17. Calculate the volume of 0.20 M $SrCl_2$ solution that is needed to completely precipitate the sulfate ions in the beaker of alum solution. Measure out twice the volume that you have calculated, and slowly add it to the beaker of alum solution. Stir the mixture to ensure complete mixing of the reagents.

18. Select one of the two methods below for preparing the precipitate:
    - Set up a ring stand, ring and wire gauze for heating over a lab burner. Place a watch glass over the beaker and heat the beaker of your reaction mixture over a lab burner. Heat the mixture to near boiling for 15 minutes. This step helps collect the particles of precipitate to a larger size and eases the filtering process.
    - Use a watch glass to cover the beaker of reaction mixture. Store the beaker in a safe place overnight.

19. Allow the mixture to cool. Filter the beaker of precipitate through the Gooch crucible with a filter paper. Add liquid to the crucible very slowly. Use a rubber policeman to scrape all of the precipitate from the beaker to the crucible. Wash the beaker and the crucible several times with small amounts of distilled water.

20. Carefully move the crucible (or filter paper) of precipitate to a small beaker and place it in a drying oven. If you are using filter paper, either air dry the paper or place it in an oven that is no warmer than 50°C to prevent charring of the filter paper.

21. After the precipitate is dry and cool, measure and record its mass.

Data Tables

Synthesis

Mass of Aluminum Foil	1.0703g
Mass of Filter Paper	2.2853g
Mass of Filter Paper and Alum Sample	15.2969g

Volume of 3M KOH	25.0mL
Volume of H_2SO_4	34.8mL

Analysis

Part 1, Determine the Melting Temperature of Alum

Trial 1 of Our Solution

Starting Heat	54.4°C
Final Heat	92.9°C

Trial 2 of Our Solution

Starting Heat	57.2°C
Final Heat	92.2°C

Trial 1 of the Stock Solution

Starting Heat	50.8°C
Final Heat	92.3°C

Trial 2 of the Stock Solution

Starting Heat	60.2°C
Final Heat	94.8°C

Part 2, Determine the Water of Hydration of Alum

Our Sample

Mass of crucible, crucible cover	24.3862g
Mass of crucible, cover, alum Preheating	26.3998g
Mass of crucible, cover, alum After First Heating	25.4375g
Mass of crucible, cover, alum After Second Heating	25.4354g

Stock Solution

Mass of crucible, crucible cover	22.4170g
Mass of crucible, cover, alum Preheating	24.6623g
Mass of crucible, cover, alum After First Heating	23.5409g
Mass of crucible, cover, alum After Second Heating	23.5400g

Part 3, Determine the Percent Sulfate of Alum

	Our Alum	Stock Alum
Mass of filter paper	2.1717g	2.2589g
Mass of alum	1.0144g	1.1333g
Mass of filter paper and $SrSO_4$	3.0211g	3.2403g
Volume of 0.20M $SrCl_2$	42.0mL	42.0mL

Calculations

1. **Determine the theoretical yield of the alum. Use the aluminum foil as the limiting reagent and presume that the foil was pure aluminum.**

$2Al + 2KOH + 2H_2SO_4 + 22H_2O \rightarrow 2KAl(SO_4)\bullet 12H_2O + H_2$

$$1.0703g\ Al \times \frac{1\ mol\ Al}{26.98g\ Al} \times \frac{2\ mol\ 2KAl(SO4)\ 12H2O}{2\ mol\ Al} \times \frac{474.3884\ g\ 2KAl(SO4)\ 12H2O}{1\ mol\ 2KAl(SO4)\ 12H2O} = 18.82\ g\ 2KAl(SO4)\ 12H2O$$

2. **Calculate the percent yield of your alum crystals.**

Mass of alum and filter paper – mass of filter paper = mass of alum

15.2969g – 2.2853g = 13.0116g

$$\frac{13.0116g}{18.82g} \times 100 = 69.14\%\ yield$$

3. **Discuss the factors that affected the percent yield.**

   One huge factor that affected my group's percent yield of alum was the filtering process. We could tell that some of our alum precipitate fell through the filter paper and into the beaker. Therefore, our mass of alum and filter paper was a lot smaller than it should've been.

4. **Write the balanced net ionic equations for the following: (a) aluminum and potassium hydroxide, yielding $[Al(OH)_4]^-$ and hydrogen gas; (b) hydrogen ions and $[Al(OH)_4]^-$, yielding aluminum hydroxide; (c) aluminum hydroxide and hydrogen ions, yielding $[Al(H_2O)_6]^{3+}$; and (d) the formation of alum from potassium ions, sulfate ions, $[Al(H_2O)_6]^{3+}$, and water.**

a. $2Al(s) + 4KOH(aq) + 6H_2O(l) \rightarrow KAl(OH)_4(aq) + 3H_2(g)$

b. $2Al(s) + 2OH^-(aq) + 6H_2O(l) \rightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

c. $Al(OH)_4^-(aq) + H^+(aq) \rightarrow Al(OH)^3(s) + H_2O(l)$

d. $K^+(aq) + Al^{3+}(aq) + 2SO_4^{2-}(aq) + 12H_2O(l) \rightarrow KAl(SO_4)_2 \bullet 12H_2O(s)$

5. **Describe a synthesis reaction.**

   A synthesis reaction is when 2 or more elements/compounds react to create a complex compound. A+B→AB.

6. **Describe how the solubility of alum in various solvents and water at different temperatures was used in conducting the experiment.**

   Alum is soluble in water but insoluble in ethanol. We used ethanol to wash the filter paper and transfer the alum crystals so they wouldn't dissolve in water.

7. **Write a detailed description of the alum crystals.**

   My alum crystals looked more like fluffy powder than crystals. But the stock solution crystals were more defined like actual crystals and didn't clump.

8. **How many moles of aluminum did you start with?**

$$1.0703g\ Al\ \times \frac{1\ mol}{26.98g\ Al} = 0.03967\ mol\ Al$$

$$\frac{1.0703g\ Al}{18.82\ g\ \ KAl(SO_4)_2\ 12H2O} \times 100 = 5.687\%\ Al\ in\ our\ alum$$

9. **How many grams of water were in your original sample? How many moles?**

   Our Alum

   Mass of crucible, cover, sample – Mass of crucible, crucible cover= Mass of hydrous alum

$$26.3998g - 24.3862g = 2.0136g$$

Mass of crucible, cover, sample after second heating – Mass of crucible, crucible cover= Mass of anhydrous alum

$25.4354\text{g} - 24.3862g = 1.0492g$

Mass of hydrous alum - Mass of anhydrous alum= Mass of water present

$2.0136g - 1.0492g = 0.9644g\ H_2O$

$$\frac{Mass\ of\ water\ present}{Mass\ of\ hydrous\ alum} \times 100 = Percent\ water$$

$$\frac{0.9644g\ H_2O}{2.0136g} \times 100 = 47.89\%\ H_2O$$

$$Mass\ of\ original\ sample\ of\ alum\ \times\ percent\ of\ water = mass\ of\ water\ in\ alum$$

$13.0116\text{g}\ \times\ 0.4789 = 6.231\text{g}\ H_2O\ in\ alum$

$$6.231\text{g}\ H_2O \times \frac{mol\ H_2O}{18.02g\ H_2O} = 0.3458mol\ H_2O\ in\ alum$$

Stock Alum

Mass of crucible, cover, sample – Mass of crucible, crucible cover= Mass of hydrous alum

$24.6623\text{g} - 22.4170\text{g} = 2.2453g$

Mass of crucible, cover, sample after second heating – Mass of crucible, crucible cover= Mass of anhydrous alum

$23.5400\text{g} - 22.4170\text{g} = 1.1230g$

Mass of hydrous alum - Mass of anhydrous alum= Mass of water present

$2.2453g - 1.1230g = 1.1223g\ H_2O$

$$\frac{Mass\ of\ water\ present}{Mass\ of\ hydrous\ alum} \times 100 = Percent\ water$$

$$\frac{1.1223g\ H_2O}{2.2453g} \times 100 = 49.98\%\ H_2O$$

$$Mass\ of\ hydrous\ alum\ \times\ percent\ of\ water = mass\ of\ water\ in\ alum$$

$$2.2453g\ \times\ 0.4998 = 1.1222\text{g}\ H_2O\ in\ alum$$

$$1.1222\text{g}\ H_2O \times \frac{mol\ H_2O}{18.02g\ H_2O} = 0.06228mol\ H_2O\ in\ alum$$

10. **How many moles of sulfate were in your original sample? How many grams?**

Our Alum

$$\text{Mass of filter paper and Sr}SO_4 - \text{Mass of filter paper} = \text{Mass of Sr}SO_4$$

$$3.0211\text{g} - 2.1717\text{g} = 0.8494\text{g Sr}SO_4$$

$$0.8494\text{g Sr}SO_4 \times \frac{mol\ \text{Sr}SO_4}{183.68g\ \text{Sr}SO_4} \times \frac{mol\ SO_4}{mol\ \text{Sr}SO_4} \times \frac{96.06g\ SO_4}{mol\ SO_4} = 0.4442g\ SO_4$$

$$\frac{Mass\ of\ SO_4}{Mass\ of\ alum} \times 100 = \%\ SO_4\ in\ alum$$

$$\frac{0.4442g\ SO_4}{1.0144\text{g}} \times 100 = 43.79\%SO_4\ in\ alum$$

$$0.4442g\ SO_4 \times \frac{mol\ SO_4}{96.06g\ SO_4} = 0.004624mol\ SO_4$$

Stock Alum

$$\text{Mass of filter paper and Sr}SO_4 - \text{Mass of filter paper} = \text{Mass of Sr}SO_4$$

$$3.2403\text{g} - 2.2589\text{g} = 0.9814\text{g Sr}SO_4$$

$$0.9814\text{g Sr}SO_4 \times \frac{mol\ \text{Sr}SO_4}{183.68g\ \text{Sr}SO_4} \times \frac{mol\ SO_4}{mol\ \text{Sr}SO_4} \times \frac{96.06g\ SO_4}{mol\ SO_4} = 0.5132g\ SO_4$$

$$\frac{Mass\ of\ SO_4}{Mass\ of\ alum} \times 100 = \%\ SO_4\ in\ stock\ alum$$

$$\frac{0.5132g\ SO_4}{1.1333\text{g}} \times 100 = 45.28\%SO_4\ in\ stock\ alum$$

$$0.5132g\ SO_4 \times \frac{mol\ SO_4}{96.06g\ SO_4} = 0.005342mol\ SO_4$$

11. **How many grams of potassium were in your original sample? How many moles?**

$$100\% - (\%Al + \%H_2O + \%SO_4) = \%K$$

$$100\% - (5.687\% + 47.89\% + 43.79\%) = \%K$$

$$100\% - 97.37\% = 2.630\%K\ in\ \boldsymbol{our\ alum}$$

$$Original\ mass\ of\ alum\ \times\ percent\ potassium\ in\ our\ alum = mass\ of\ potassium\ in\ our\ sample$$

$$13.0116\text{g}\ \times\ 0.0263 = 0.3422\text{g K}$$

$$0.3422\text{g K}\ \times \frac{mol\ K}{39.10g\ K} = 0.008752mol\ K$$

12. **What is your experimental Empirical Formula for your Alum?**

Assuming 100g:

$$5.687\%\ Al = 5.687g\ Al \times \frac{mol\ Al}{26.98g\ Al} = \frac{0.2108mol\ Al}{0.0676mol} \approx 3 \times 4 = \mathbf{12}$$

$$47.89\%\ H_2O = 47.89g\ H_2O \times \frac{mol\ H_2O}{18.02g\ H_2O} = \frac{2.657mol\ H_2O}{0.0676mol} \approx 39 \times 4 = \mathbf{156}$$

$$43.79\%\ SO_4 = 43.79g\ SO_4 \times \frac{mol\ SO_4}{96.06g\ SO_4} = \frac{0.4559mol\ SO_4}{0.0676mol} = 6.74 \times 4 \approx \mathbf{27}$$

$$2.630\%\ K = 2.630g\ K \times \frac{mol\ K}{39.10g\ K} = \frac{0.0676mol\ K}{0.0676mol} = 1 \times 4 = \mathbf{4}$$

$$K_{\mathbf{4}}Al_{\mathbf{12}}(SO_4)_{27}\bullet 156H_2O$$

13. **Is your sample alum? Use the results of the three tests to support your answer. Discuss the accuracy of your tests and possible sources of experimental error.**

According to my empirical formula, my sample isn't even close to being actual alum. I had many small sources of error which all add up to results that aren't close to the theoretical. I think my biggest error was filtering my solutions before they were cool. A lot of my precipitate just went straight through the filter.

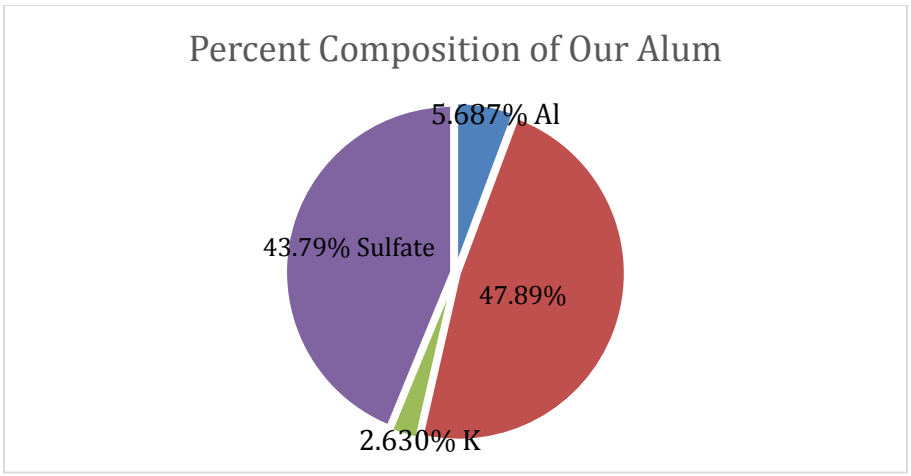
14. **Suggest other tests that could be conducted to verify the composition of your alum.**

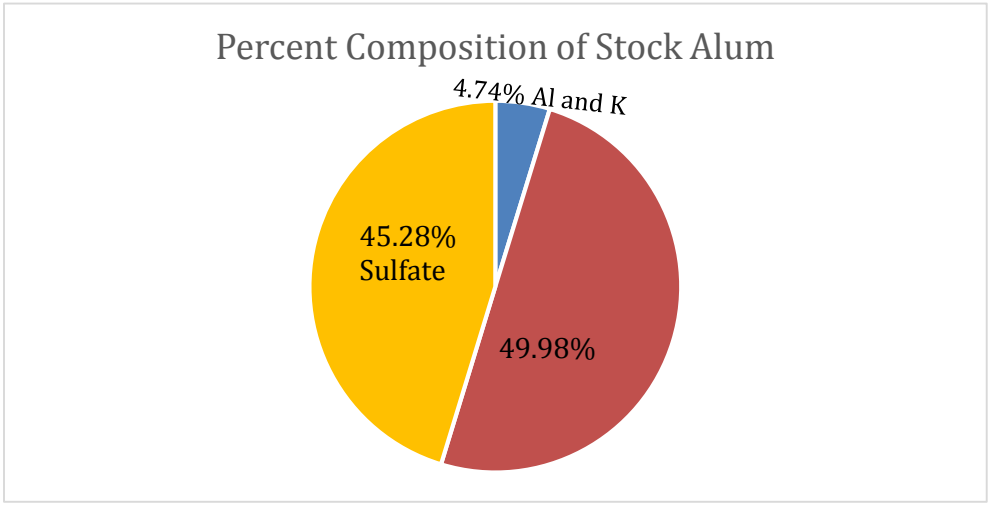
    One test that could be used to verify the composition of your alum is colorimetric determination of alum. This is the absorbance rate of alum.

15. **If the melting temperature test was the only test that you conducted, how confident would you be in the identification of your sample? Explain.**

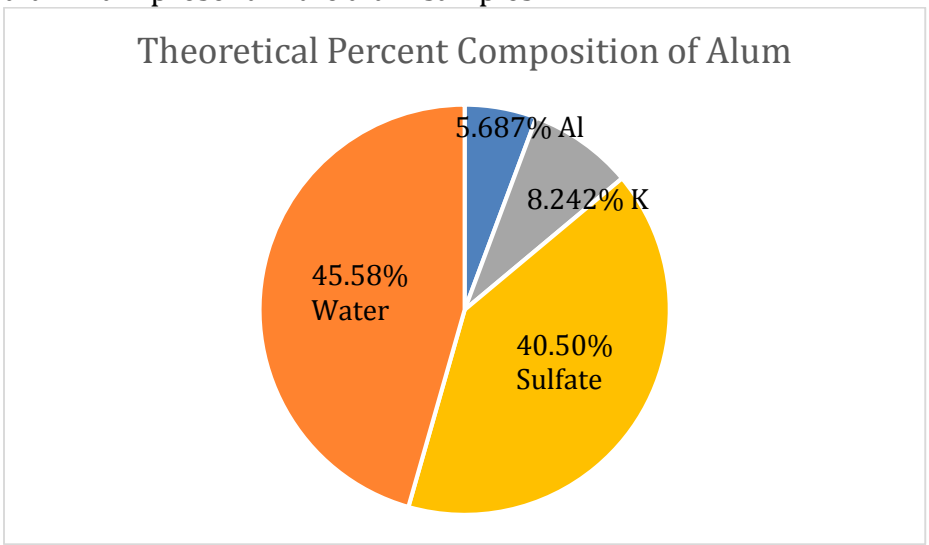
The melting temperature test is very unreliable. My lab is full of errors, yet I got 0.0541% error.

Graphs

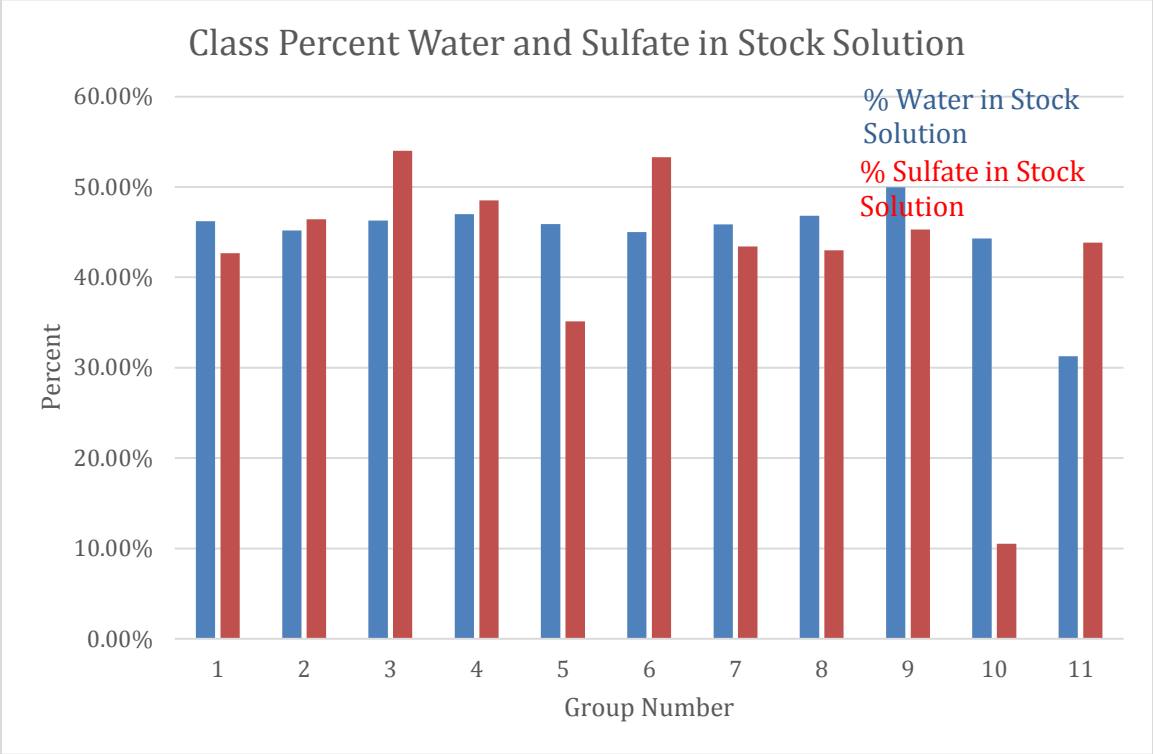




The percent compositions are pretty close for my alum and the stock alum. This shows that we repeated the errors we made. This also shows that we had very little aluminum present in the alum samples.



This graph shows that theoretically the percent of Al and K would be about 14% together. My alum sample and stock alum had way less than 14% total for Al and K.



This graph of class data shows that the class as a whole got relatively close percents of water and sulfate in the stock solution.

Error Analysis

1. **Calculate the percent yield of alum.**

$$\frac{13.0116g}{18.82g} \times 100 = 69.14\%\ yield$$

2. **Calculate the percent error in the melting point of your alum.**

$$Percent\ error = \left|\frac{Theoretical - Experimental}{Theoretical}\right| \times 100$$

$$\left|\frac{92.5 - \left(\frac{92.9 + 92.2}{2}\right)}{92.5}\right| \times 100 = 0.0541\%\ error$$

3. **Calculate the percent error of amount of water**

$$\frac{8.5760g - 6.231g}{8.5760g} \times 100 = 27.34\%\ error$$

4. **Calculate the percent error of the percent sulfate.**

$$\frac{7.621g - 5.698g}{7.621g} \times 100 = 25.23\%\ error$$

5. **Given the above answers to 2-4, discuss the probability that you produced alum.**

   I probably didn't produce alum because 25.23% and 27.34% error is a large amount of inaccuracy.

6. **If the alum were not dry before analysis, what would be the effect on the experimental formula?**

   If the alum wasn't dry, the experimental formula would have a higher amount of moles of water.

7. **If some of the alum were lost during drying in the crucible, what would be the effect on the experimental formula?**

The mass of alum lost would be considered evaporated water that I determined in part 2 of the analysis. This would make it look like my alum sample had more water than it truly did.

8. **If some of the strontium sulfate precipitate passed through the filter, how will that affect the results?**

   If some of the strontium sulfate went through the filtration, there would be less mass collected by the filter paper. This is why I got 25.23% error for sulfate.

9. **Give at least two additional sources of error for this lab. Describe in detail how those errors would impact your final results.**

   One source of error was that we forgot to heat the crucible before finding the mass. There could've been water molecules in it, which would've lead to the crucible having a higher mass. This would lead to having a lower mass of alum than what you should've gotten.

   Also, our solutions weren't completely cool when we filtered them. Since the solutions were a little warm some of the precipitate would've filtered straight through. This led to calculating a lower amount of precipitate.

10. **Give at least two possible improvements to the lab procedure. Explain in detail how these improvements could impact your final results.**

    One small improvement would be to have 2 filter apparatuses. This way you wouldn't have to wait for the first solution to filter to start the filtering of the second. This would've sped up the process and we'd be able to spend more time allowing the solutions to cool before filtering because we could do them at the same time. This extra bit of time would lead to having a lower percent error.

    The lab procedure was pretty direct so there's not much you could change. But hypothetically, the lab could be done in one day, which would lead to having less error. Anything can happen to our samples sitting out over the weekend.

<u>Conclusion</u>

After finding that the theoretical yield of alum was 18.82g, we found that our sample only had a percent yield of 69.14% alum. My sample's average melting point was 92.55°C compared to the theoretical 92.5°C. Water of hydration and percent sulfate led to finding the percent composition of alum. My sample of alum was made up of 43.79% sulfate, 47.89% water, 5.687% Al, and 2.630% K. The percent composition

was then used to find that the empirical formula of my alum was $K_{\mathbf{4}}Al_{\mathbf{12}}(SO_4)_{27}\bullet 156H_2O$. The actual empirical formula of alum is $KAl(SO_4)_2\bullet 12H_2O$. This shows that I didn't create alum. I had many sources of error which affected my overall outcome.