Name ____________________________ Lab Section_______________

Chemistry 132 Lab 05 Making Alum from Aluminum Metal

Prelaboratory Exercise

1. Show **how** equation (4) is obtained by adding equations (1), (2), and (3)
2. Calculate the molar mass of alum, $KAl(SO_4)_2 \cdot 12\ H_2O$.

Introduction

Recycling scrap aluminum into fresh metal is an effective way to conserve energy, since it saves 95% of the energy used in Al metal production. For this reason, approximately 31% of all aluminum produced in the United States comes from recycled scrap. Recycling aluminum is also mandatory in many cities and towns in the United States. In this experiment we will use aluminum metal from a beverage can as the starting material (reagent) for the synthesis of alum, an inorganic compound.

Alum is the common name for potassium aluminum sulfate dodecahydrate, $KAl(SO_4)_2 \cdot 12\ H_2O$ (Figure 1). Alum is an ionic compound. It has two different cations, K^+ and Al^{3+}, whose total charge of +4 is opposite in sign of the total charge of the two SO_4^{2-} anions (-4). Alum also contains 12 water molecules in its formula. Six water molecules surround each of the two cations in alum.

Figure 1. Formula of alum.

$$KAl(SO_4)_2 \cdot 12\ H_2O$$

Cations (K^+ and Al^{3+})

Anions (SO_4^{2-})

12 Water Molecules

Alum has a number of applications. Most grocery stores have alum on the shelves as a pickling agent to help pickles retain their crispness. It can also be used to clear up cloudy water in swimming pools, as a bonding agent for dyes in the textile industry, in antiperspirants to block the flow of sweat from the sweat glands, and in steptic pencils to stop bleeding.

In this experiment, you will synthesize alum by a four-step process. You will isolate alum by vacuum filtration and calculate the percent yield for the reaction. Lastly, you will recrystallize the product by a process called slow solvent diffusion. This process encourages crystallization to begin at a limited number of sites which results in larger, better-shaped crystals.

Experimental

1. Dissolution of Aluminum Can

Use scissors to cut into small pieces between 1 and 1.5 g of aluminum from a beverage can and place them in a 150-mL beaker. **Warning: be careful not to cut your fingers on the can.** Record the exact mass that you used below.

→Mass of aluminum can pieces ____________________________________ g

Add 50 mL of 1.4 M KOH (potassium hydroxide) to the aluminum can pieces in the beaker under the fume hood. **Warning: KOH is a corrosive chemical. Wear your safety glasses and avoid contact**

with your skin. Gently heat the solution on a hot plate under the hood, stirring with a glass rod. Continue heating until all of the aluminum dissolves and is completely reacted. (Solid impurities may still be present.)

The reaction for this process is:

$$2\ Al\ (s)\ +\ 2\ KOH\ (aq)\ +\ 6\ H_2O\ (l)\ \longrightarrow\ 2\ KAl(OH)_4\ (aq)\ +\ 3\ H_2\ (g) \qquad (1)$$

Allow the solution to cool for a few minutes. Gravity filter the solution into a second 150 mL beaker to remove the paint and other impurities. Throw the filter paper away in the garbage.

2. Formation of Aluminum Hydroxide

While stirring with your glass rod, slowly and carefully add 30 mL of 6 M H_2SO_4 (sulfuric acid). **Warning: H_2SO_4 is a corrosive chemical. Wear safety goggles and avoid contact with your skin. In addition, H_2SO_4 and KOH react violently with each other. Add slowly and carefully.** A white precipitate ($Al(OH)_3(s)$) should form during the addition process. The reaction is:

$$2\ KAl(OH)_4\ (aq)\ +\ H_2SO_4\ (aq)\ \longrightarrow\ 2\ Al(OH)_3\ (s)\ +\ K_2SO_4(aq)\ +\ 2\ H_2O(l) \qquad (2)$$

3. Formation of Alum

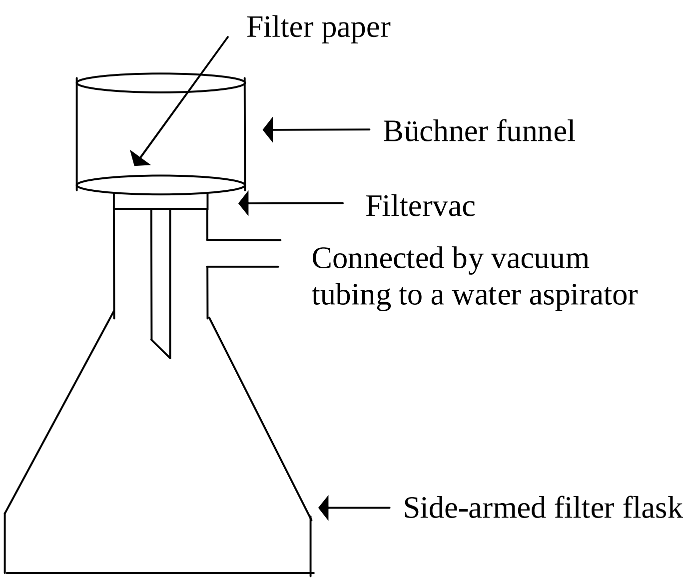
Gently heat the mixture. Allow it to boil gently (reflux) for five minutes and cool five minutes. If all the solid did not dissolve, gravity filter the solution into a third 150 mL beaker. Place the beaker containing the solution into an ice bath for 20 minutes. Stir occasionally with a clean stirring rod. White crystals of alum will form at the bottom of the beaker. The reaction is:

$$2\ Al(OH)_3\ (s)\ +\ 3\ H_2SO_4\ (aq)\ +\ K_2SO_4\ (aq)\ +\ 18\ H_2O(l)\ \longrightarrow\ 2\ KAl(SO_4)_2 \cdot 2\ H_2O\ (s) \qquad (3)$$

4. Vacuum Filtration of Alum

While your alum is crystallizing, set up a vacuum filtration device as shown below using a side-armed flask, a filtervac, a Büchner funnel, and a piece of filter paper. Place the filter paper in the funnel, and the funnel in the filtervac and the side-armed flask.

Figure 2. Vacuum filtration set-up.



Connect the side-arm of the flask to a water aspirator and turn on the water. Carefully pour the alum crystals through the filter paper, maintaining downward pressure on the Büchner funnel to maintain the vacuum. Use a rubber policeman to quantitatively transfer your crystals to the filter paper. Maintain the vacuum on the crystals for 5 minutes, then remove the tubing from the side arm flask and turn off the water.

Weigh a clean, dry 50 mL beaker and record the value below. Transfer your crystals to the 50 mL and label the beaker with your name, lab section, and lab time. Cover the beaker, and allow the crystals to dry until next week in a location designated by your instructor.

→Mass of 50 mL beaker ____________ g

→Mass of beaker plus dried Alum crystals (week 2) ____________ g

→Mass of Alum crystals ____________ g

5. Week Two

Determine the mass of alum produced last week and record the value. You can now complete the % yield calculation. Dispose of your alum in an alum waste bottle.

Calculations

The overall balanced equation for the synthesis of alum may be obtained by adding equations (1), (2), and (3) to obtain

$$2\ Al\ (s) + 2\ KOH\ (aq) + 4\ H_2SO_4\ (aq) + 22\ H_2O(l) \rightarrow 2\ KAl(SO_4)_2{\cdot}12\ H_2O\ (s) + 3\ H_2(g) \qquad (4)$$

Use equation (4) and the mass of aluminum can you used to calculate the following, <u>showing your work</u>. Remember, you calculate the moles of aluminum from the mass of aluminum using its molar mass. The moles of alum (theoretical) are calculated from the stoichiometry of equation (4). The mass of alum (theoretical) is calculated using the molar mass of alum. The actual mass of alum is the amount that you obtained on the filter paper. The percent yield equation is shown below. Refer to your text book if you need help with these calculations.

$$\%\ \text{yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Moles of aluminum ___________ moles

Moles of alum (theoretical) ___________ moles

Mass of alum (theoretical) ___________ g

Mass of alum (actual) ___________ g

Percent yield of alum ___________ %

Questions

1. How many grams of H_2 gas were produced, assuming that the aluminum metal, Al(*s*), reacted completely? (In other words, what is the ***theoretical yield*** of hydrogen gas?)

2. Presumably your percent yield was not 100%. In what steps of the procedure do you think that product might have been lost? Where did the product go?