Experiment 38

FV 1/9/2008

CONVERSION OF ALUMINUM TO ALUM

MATERIALS: 50 mL beakers (4), 10 mL graduated cylinder, glass rod, suction filtration apparatus and paper (1), gravity filtration funnel and paper (1), filter paper for crystal drying, small weigh boat, hot plate (1), aluminum turnings, 2 M KOH, 6 M H_2SO_4, potassium aluminum seed crystals, 50% ethanol/water, ice.

PURPOSE: The purpose of this experiment is to convert aluminum metal to potassium aluminum sulfate crystals.

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

1. Explain the process of converting aluminum to alum.
2. State some practical uses of alum.
3. Form a crystalline product and efficiently collect it from a reaction mixture.
4. Calculate theoretical and percent yields of a reaction.

DISCUSSION[1]

In 2006, 51.9 billion aluminum cans were recycled in the United States. This number represents just over half of the cans that could have been recycled. The recycling of an aluminum can into a new can uses 95% less energy than making one from the ores bauxite (Al_2O_3) or cryolite (Na_3AlF_6). The recycling process involves shredding the used cans and heating the material to remove any painted or paper labels. The metal is then melted in a furnace and some virgin aluminum is added to the recycled material. The molten aluminum is then formed into large ingots that can then be rolled into aluminum sheets that are used to make new cans.

In this experiment, you will be "recycling" aluminum scrap in a very non-traditional way but you will produce two useful products; hydrogen gas and potassium aluminum sulfate ($KAl(SO_4)_2 \cdot 12\ H_2O$) which is also known as alum. Hydrogen gas can be used as a very clean burning fuel. Alum has many uses which you will discover as part of this laboratory experiment. The reactions that govern the processes in this experiment are:

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

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

$$2\ Al(OH)_3\ (s) + 3\ H_2SO_4\ (aq) \rightarrow Al_2(SO_4)_3\ (aq) + 6\ H_2O\ (l) \quad (3)$$

$$Al_2(SO_4)_3\ (aq) + K_2SO_4\ (aq) + 24\ H_2O\ (l) \rightarrow \underset{\textbf{(alum)}}{2\ KAl(SO_4)_2 \cdot 12\ H_2O} \quad (4)$$

PROCEDURE (work in pairs)

1. Obtain ~0.2 g of aluminum scrap. Use the analytical balance and record the mass of your metal to 4 decimal places on the "In-lab Questions" page.
2. Place the metal in a 50 mL beaker and add 10 mL of 2 M KOH to the metal. <u>Be sure to do this in the hood.</u>
3. Heat the reaction mixture gently on a hot plate until no more bubbles are produced from the reaction (~10 minutes). Do not boil the mixture.
4. While your mixture is heating, set up a gravity filtration apparatus. Be sure to wet the filter paper with water after placing it in the glass funnel. Answer in-lab question #2.
5. When the reaction is complete, carefully filter the warm mixture and collect the filtrate in a clean 50 mL beaker. Rinse the filter paper with 5 mL of distilled water and collect the rinsing in the same 50 mL beaker as above.
6. Slowly add 5 mL of 6 M H_2SO_4 to the filtrate while stirring the mixture with a clean glass rod. Answer in-lab question #3.
7. Heat the resulting mixture until the crystals dissolve (~10 minutes). Do not boil the mixture.

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[1] Information in the discussion section obtained from http://science.howstuffworks.com/recycling4.htm, http://intro.chem.okstate.edu/1515SP01/Laboratory/12Recycling%20Al.pdf, http://employees.oneonta.edu/kotzjc/LAB/Alum_Expt.pdf, http://icn2.umeche.maine.edu/newnav/NewNavigator/labs/Alum__7218.htm

8. Cool the clear solution in an ice bath. Crystals should form after 15 minutes. If crystals do not form upon cooling, see you instructor for a "seed crystal" to help the process. While your mixture cools, answer in-lab question #4.
9. Set up a suction filtration apparatus to collect your crystals. Be sure to wet the filter paper that you place in the Buchner funnel with water.
10. Slowly transfer all of your crystals to the Buchner funnel. To transfer any crystals that remain in the beaker, rinse it with 5 mL of cooled 50% ethanol/water solution and slowly pour that solution into the Buchner funnel.
11. Allow the crystals to dry on the suction filtration apparatus for several minutes then transfer all of them to a larger piece of filter paper. Fold the paper in half over them to remove any remaining liquid from the crystals.
12. Weigh your dry crystals on the analytical balance and record the mass to 4 decimal places in the data table on the "In-lab Questions" page. Answer in-lab question #5.

Name _____ Section _____

Partner _____ Date _____

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IN-LAB QUESTIONS

1. Data:

Mass of aluminum scrap used	**Mass of alum produced**	**% yield**

2. Which reactant, Al or KOH is in excess in this reaction? Show your work.

3. Write the equation, see discussion section, that describes this process. Do your observations of this reaction match the products in the equation? Explain.

4. From the mass of scrap metal you used and the equations that govern the reactions that you carried out, calculate the theoretical yield of alum. Check your answer with your instructor.

5. Calculate the % yield of alum. Report your answer in the table above and comment on its value (i.e. reasons you believe it's too high or too low).

Name _____ Date _____

PRE-LAB QUESTIONS
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Complete these questions prior to attending lab.

1. In this experiment you will be making alum from aluminum metal. Find and describe an additional way to make alum. Be sure to site your source(s).

2. Find and describe 4 uses for alum. Be sure to site your source(s).

3. How many moles of alum are in 0.1425 g of alum?