The Reaction of Aluminum with a Strong Acid

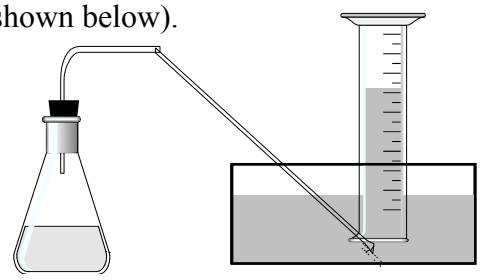
(Determining the formula of aluminum chloride using experimental data)

In this experiment, we will be exploring the reaction of aluminum with hydrochloric acid to produce aluminum chloride and hydrogen gas. By designing a series of experiments, you will be able to experimentally determine the stoichiometry of the reaction and the correct formula of the aluminum chloride product. Although you may already know the correct formula for aluminum chloride, the purpose of this experiment is to use experimental data to determine the correct empirical formula. In most experiments, it is important to look for trends in the data that is being collected because in most experiments there will be some point where the observed trend changes. The transition point between trends often identifies an important relationship between reactants.

SAFETY NOTE: Hydrochloric acid can cause skin burns. If you spill acid on yourself, wash the affected area immediately with running water. If you spill acid on the bench, use the sodium bicarbonate in the spill kit to neutralize the acid. Hydrochloric acid can also damage your eyes. Wear your goggles at all times in the lab! Do not use flames during this experiment. The hydrogen gas given off can react explosively with oxygen in the atmosphere.

Experiment:

The experimental apparatus consists of a 250-mL Erlenmeyer flask from your lab drawer, a single-hole rubber stopper attached to a length of tubing, a 500-mL graduated cylinder and a large trough or tub for use as a water bath (shown below).



Prepare the experimental apparatus as shown above with the inverted graduated cylinder completely full of water. Be sure the water temperature is near room temperature. Add 5.0mL of 5.0M HCl(aq) to the Erlenmeyer flask and weigh a 0.25g (approx.) piece of Al foil. Add the foil to the flask and immediately insert the stopper. Immerse the flask in the water trough and hold it in place with a lead ring. Allow the reaction to continue until the volume of gas contained in the cylinder is constant. (Be sure to push the gas outlet tube above the level of water in the inverted cylinder as soon as gas collects.) Record the volume of gas generated in this experiment **and note the appearance and condition of the material remaining in the flask.**

- ► Has all of the Al foil been consumed? What does this observation tell you about the limiting reagent in this experiment?
- ► What variables/conditions could you change in this experiment to provide more information about the system being studied?

Design a series of experiments based upon this initial experiment/observation that will allow you to further explore the reaction of aluminum with hydrochloric acid. It is typically considered good practice in science to change only *one* variable at a time when designing a series of experiments and to change the *same* variable for the entire series of experiments. Consider the reagents available in the lab when you design your experiment and consult your instructor before you proceed with additional trials. Your experimental plan should include a testable hypothesis based upon the observations you made in the trial run and should describe a ***series*** of experiments, not simply describe the next experiment you are planning to do to test your hypothesis. What are you going to

vary in the experiment? Over what range will you vary it? Be sure to choose a wide enough range for the variable you are changing that your experiments are not effectively duplicate runs of each other. What do you expect the result to be? ***Your instructor or Lab Assistant must approve your experimental plan (written in your lab notebook) before you continue.***

It will likely be useful to organize and record your data using a table similar to the one shown below. It is usually good practice to use tables to keep data organized in your lab notebook. Be sure to include a description of the experiment being performed, and if there are any calculations required to generate any of the data in the table, you should always include an example/sample calculation below the table.

DATA TABLE (Duplicate this table in your lab notebook and record data there.)

Expt #	Mass of Aluminum Used (g)	Volume of Hydrochloric Acid Used (mL)	Concentration of Hydrochloric Acid Used (M)	Initial Volume of Gas in Graduated Cylinder (mL)	Final Volume of Gas in Graduated Cylinder (mL)	Total Volume of Gas Collected (mL)	Observations
1							
2 etc.							

In many of the experiments we perform, it is helpful to look at the data graphically to help identify trends and transitions in the behavior of the chemical system. Generate a graph or graphs that help you visualize how the volume of gas generated in each experiment is affected by changing the conditions in your experiments.
When saving graphs it is safest if you email the completed graph to each group member before leaving lab. If your graph will be submitted as part of an electronic submission on D2L, the Excel graph should be saved within the Word document of your hand-in, not submitted as a separate file.

Questions for Analysis:

The following questions are designed to help you interpret your data. It may be helpful for you to answer these questions while you are in the lab and can interact with the instructor but you are not required to record the answers to these questions in your lab notebook.
Your notebook copy pages are not a substitute for a lab hand-in. The lab hand-in is a separate assignment that should be downloaded from the D2L page, filled in, and submitted according to your instructor's directions.

1. Describe any trends or transitions present in your graph(s). What do these trends and transitions tell you about the system?

2. How are the trends and transitions in your graph(s) related to the *limiting reagent* in each experiment?

3. ***Based upon your experimental results***, write a correctly balanced equation for the reaction of aluminum with hydrochloric acid. Is this experiment-derived stoichiometry consistent with the stoichiometry you would expect based upon most likely charges of all species involved? Is the difference (error) significant?