Analysis of a Chemical Mixture Using the Ideal Gas Law

PRELAB:

Reading:

1. Sections 10.4 & 10.6 of Brown, LeMay, Bursten, and Murphy.
2. This handout.

Questions:

Silver oxide can be decomposed to yield silver metal and oxygen gas according to the equation below. You conduct this reaction with an unknown mass of Ag_2O, and collect 81.2 mL of O_2 over water. If the ambient temperature is 23 °C and the pressure is 751 mmHg, what mass of Ag_2O did you start with? (The vapor pressure of water at 23 °C is 21.1 mmHg.)

$$2\ Ag_2O_{(s)} \rightarrow 4\ Ag_{(s)} + O_{2\,(g)}$$

INTRODUCTION:

The evolution of gas as part of a chemical reaction can be a useful feature in determining the identity, quantity, or purity of chemical compounds. For instance, given a mixture of two somewhat similar compounds in which only one will react and evolve gas in the presence of another specific reagent, the mass percentage of the compounds can be discerned by measuring the quantity of gas evolved in the reaction.

In this lab you will be given a mixture of sodium chloride (NaCl) and sodium nitrite ($NaNO_2$) – the composition of this mixture will be 'unknown'. You will quantitatively measure the amount of product formed by the reaction of one of the components under conditions where the other component is inert and does not react. One of the products of the reaction is a gas, which can be collected and its volume can be determined under measured conditions of pressure and temperature. The number of moles of gaseous product can be calculated using the Ideal Gas Law. The moles of product can be related to the moles and mass of the reactant from which the product was formed. By knowing the mass of the one component that reacted, the mass of the other component can then be determined by difference from the total mass of the chemical mixture tested. Finally, percent composition by mass can be calculated

Each group will react the same sample three times, each time with an excess of sulfamic acid, HSO_3NH_2. The NaCl is unreactive under these conditions, whereas the $NaNO_2$ reacts to form nitrogen gas according to the reaction equation given below. The N_2 gas will be collected at atmospheric pressure and room temperature. Each group will calculate the moles of N_2, the moles of $NaNO_2$, the mass of $NaNO_2$, the mass of NaCl, and the percent composition by mass of $NaNO_2$ and NaCl in the mixture.

$$\mathbf{NO_2^-{}_{(aq)} + HSO_3NH_{2(aq)} \longrightarrow HSO_4^-{}_{(aq)} + H_2O_{(l)} + N_{2(g)}}$$

PROCEDURE[1]: **(REFER TO FIGURE 1.)**

Working with a partner you will use an apparatus similar to that shown in Figure 1. Weigh ~0.18 g of sulfamic acid, HSO_3NH_2, remove stopper **A**, and add the sulfamic acid to the given 50-mL Erlenmeyer flask. Add 10. mL of distilled water. ***CAUTION: Sulfamic acid and sodium nitrite must never be mixed together as solids. In the presence of traces of water the solids react to evolve nitrogen and heat so rapidly as to be dangerous***.

Weigh just over 0.1 g of the chemical mixture from your group's sample into a ***dry*** 1-dram vial. Add 1 mL of distilled water to the vial, and lower the vial carefully into the Erlenmeyer flask. It should rest against the bottom and side of the Erlenmeyer flask without allowing any solution to either enter or leave the vial.

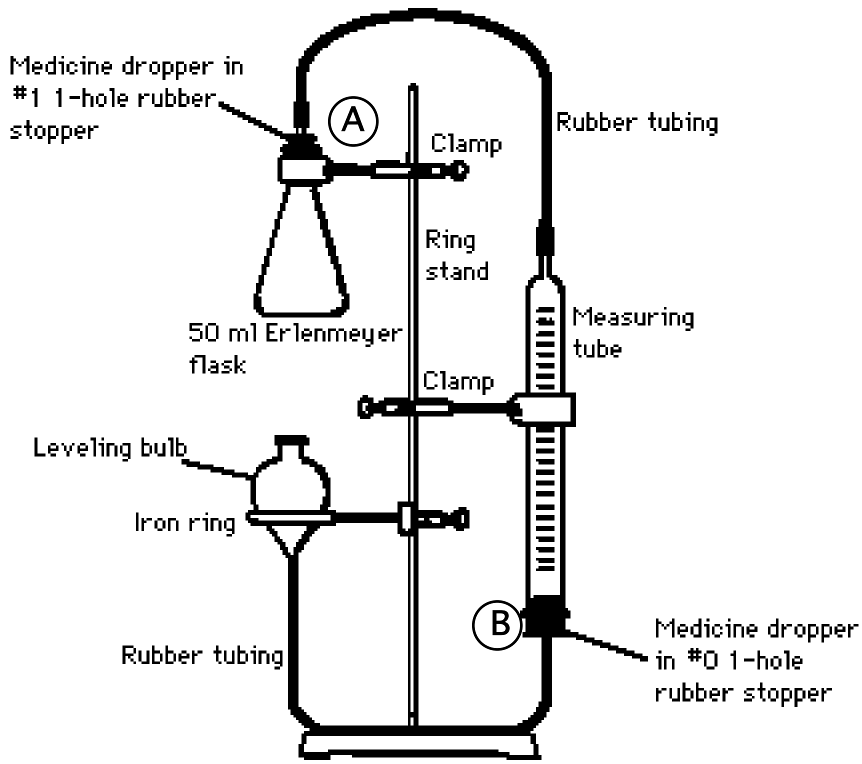

Figure 1. Apparatus for reaction of a mixture.

Sufficient water has been added to the leveling bulb. By raising the bulb appropriately, you should be able to fill the measuring tube to within 1 mL of the upper calibration mark (at 50.00mL) when the water level in the bulb is the same as in the measuring tube. Check the apparatus for leaks by inserting stopper A securely and lowering and raising the leveling bulb. If all the joints are tight, the level of the water in the measuring tube will return to its original level when the leveling bulb is raised to its starting position.

Then insert stopper **A** securely into the Erlenmeyer flask. ***CAUTION: Be sure that the rubber tubing connecting the Erlenmeyer flask and the measuring tube is free of kinks.*** Before starting the reaction have your instructor check your apparatus. Now adjust the leveling bulb so that the water levels in the leveling bulb and the measuring tube are exactly the same. Read the initial volume indicated by the bottom of the meniscus in the measuring tube(aligned to the meniscus in the leveling bulb) and record the initial volume in your lab notebook to the nearest hundredths place. Notice how the graduations on the measuring tube are oriented; you need to *consistently* read the values from these graduations.

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[1]Adapted from Chemistry in the Laboratory by C.W.J. Scaife and O.T. Beachley, Jr., Saunders, 1987.

Tip the 50-mL Erlenmeyer flask so that some mixing of the sulfamic acid solution with the solution inside the vial occurs. Gas evolution should begin. Over the course of the reaction, periodically lower the leveling bulb so that the water levels in the leveling bulb and measuring tube are approximately the same. This reduces the gas pressure in the system and helps prevent leaks. DO NOT allow the water level to go above the 50.00mL level in the measuring tube (see Figure 1). As gas evolution decreases, tip the Erlenmeyer flask more to achieve additional mixing. Continue to mix the solutions by gentle rocking of the flask until there is no further evolution of nitrogen gas. While waiting, ~ 5 minutes to allow the contents of the flask to return to room temperature, record the room temperature. A thermometer will be located at the front of the lab. Reference the chart provided in lab to determine the vapor pressure (partial pressure) of water, using your room temperature value. Record the barometric pressure that is posted in lab.

Adjust the leveling bulb so that the water levels in the leveling bulb and the measuring tube are again exactly the same. At this point, the pressure of the gas is equal to atmospheric pressure. Read the final volume of gas in the measuring tube, and record it in your lab notebook. Clean the Erlenmeyer flask, and repeat the experiment using the same sample and a dry dram vial each time, until three successful trials have been completed.

Your experimental data needs to be entered into a grading spreadsheet before you leave lab today. Your work will be assessed on the precision & accuracy (you don't need to calculate accuracy yourself as you don't know the actual mass percentage) of your chemical mixture composition determination based on the information you provide to this spreadsheet.

What should be in your laboratory notebook?

1. Record all masses, temperatures, volumes, calculations, observations, etc.
2. Calculate the **average mass percentage, the standard deviation, the % relative standard deviation, and the % precision** for the %$NaNO_2$ in your unknown mixture sample using data from all three trials.

What should be attached to your discussion now but put into your laboratory notebook later?

The Supplemental Report Sheet.

What should be in your discussion?

Address your objective, report your results (including precision) and the significance of each. Be sure to use proper significant figures in your discussion. Identify and discuss the two most significant sources of random experimental error relative to your reported results. Additionally, address whether the % $NaNO_2$ would have been larger than, smaller than, or no different from your calculated value if (A) the partial pressure of water was ignored in the calculations, and (B) the amount of sulfamic acid added to the reaction was doubled.

Supplemental report sheet

Parameter	Trial #1	Trial # 2	Trial # 3
unknown mixture #		"same unknown number"	"same unknown number"
unknown mixture, g			
sulfamic acid, g			
starting volume, mL			
ending volume, mL			
Volume of N_2 gas collected , mL			
Volume of N_2 gas collected , L			
Barometric pressure, mmHg			
Barometric pressure, atm			
Room temp, ^{0}C			
Room temp, K			
Vapor pressure H_2O, atm			
Pressure N_2 gas, atm			
Moles N_2 collected			
Moles $NaNO_2$			
$NaNO_2$ reacted, g			
Mass% $NaNO_2$ in unknown mixture			
NaCl in unknown, g			
Mass% NaCl in unknown mixture			

average % mass $NaNO_2$= ____________________

standard deviation= ____________________

% relative standard deviation=___________________

% precision= __________________