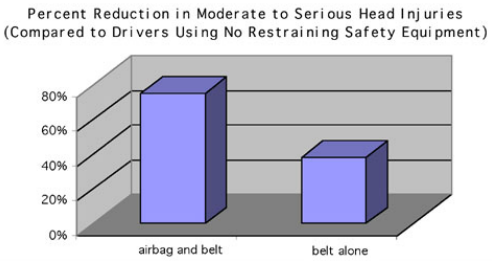
Lab 5.4
Air Bag Stoichiometry

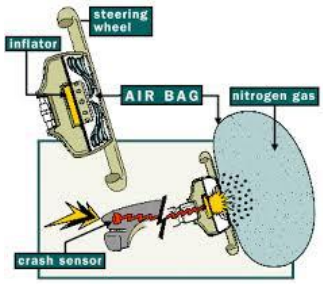
AP Chemistry

BACKGROUND

Since model year 1998, all new cars have been required to have airbags on both driver and passenger side. To date, statistics show that airbags reduce the risk of dying in the direct frontal crash by about 30%. Many people believe that the gas used to inflate the bag comes from a compressed air tank. Airbags, however, are filled with a gas as the result of a rapid decomposition reaction of the chemical sodium azide (NaN_3). The reaction that occurs completely fills a plastic bag in front of the driver or passenger preventing possible head injuries.



$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$



To be effective the airbag must inflate quickly (airbags inflate in approximately 30−40ms) and produce non-toxic products at a temperature that will not burn car occupants. Additionally, the reactants should be chemically stable, so they last for extended periods without reacting accidentally and may be disposed of safely. Decomposition of a sodium azide pellet is caused by an electric current triggered by a collision censor and produces non-toxic nitrogen gas to fill the bag.

The other product, sodium metal, is highly reactive and reacts violently with water. Secondary reactions are used to consume the sodium metal produced. The pellets also contain additives that enhance the rate at which the gas is produced while minimizing the heat. Some formulations are trade secrets, but all require a careful chemical, environmental and economic analysis. These issues, as well as the quest for better and cheaper systems, drive the research for other compounds and formulations for the gas-producing reaction used in the system.

Gas-Generator Reaction	Reactants	Products
First Reaction (Triggered by Sensor)	NaN_3	Na N_2 (g)
Second Reaction.	Na KNO_3	K_2O Na_2O N_2 (g)
Final Reaction.	K_2O Na_2O SiO_2	alkaline silicate (glass)

In this lab you will simulate the airbag reaction using a plastic sandwich bag and a different chemical reaction. We will avoid the use of explosive reactions and concentrate on a slower gas producing reaction. This exercise tests your ability to design and carry out laboratory experiments. You will be graded on experimental design, data collection skills, and on the accuracy and precision of your results. Clear thought processes and well-written responses will contribute to your success on the assignment. You must follow proper safety procedures.

The task is to generate a gas that will just fill a small resealable plastic bag using baking soda ($NaHCO_3$) and 6M HCl. The ideal result is to fill the bag to plumpness, yet not to over-inflate or under-inflate the bag; the bag may also contain unreacted chemicals and other excess products. (Hint: carbonic acid is unstable and immediately decomposes.) Try and keep waste to a minimum by using as little chemicals as possible. You will be asked to describe the method you develop to solve the problem. You must complete the assignment during this class period and you may not share information between groups.

Safety

- The hydrochloric acid is concentrated and will be corrosive to skins and eyes.
- Spills should be neutralized and cleaned up immediately. Any solutions that contact skin should be rinsed off with plenty of water.
- Goggles and aprons must be worn.

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I. PURPOSE

To design and produce a model airbag (including necessary calculations) using hydrochloric acid and baking soda that approximates the behavior of an automobile airbag.

II. MATERIALS

1. 6*M* HCl
2. Sodium bicarbonate ($NaHCO_3$)
3. Electronic Balance
4. Plastic Sandwich Bag
5. Thermometer
6. Barometer
7. Graduated cylinders
8. Chemical scoop
9. Condiment cups
10. Disposable pipettes
11. Weighing Paper

III. PRE-LAB QUESTIONS

1. How is the reaction in this experiment similar to the reaction in a real airbag? How is it different?
2. What is the starting point for all calculations necessary in this lab?
3. Based on the chemicals available for this lab, which is the better choice for the limiting reactant?
4. Calculate the molar volume of a gas at room temperature (25.0°C).

IV. PROCEDURES

1. As a group, create a plan for the design of the project and record in lab book. In the procedural plan include experimental data to collect and all calculations needed to run the experiment.
   a. Plan for production of the airbag: *(list steps here)*
2. Create an observation data table to be filled in when during the lab.
3. Have the plan approved before you begin.
4. Carry out the plan. Record observations in the created data table.

V. DATA & CALCULATIONS

A. <u>DATA</u>

B. <u>CALCULATIONS</u>
(Show necessary calculations here with labels.)

VI. QUESTIONS & DISCUSSION OF ERROR

A. <u>QUESTIONS</u>

1. Revisions: What would you do differently a second time around to improve results? There is ALWAYS room for improvement.
2. In your lab did you calculate the exact amounts of both reactants to fill the bag? If so, was this necessary? Why or why not?
3. Your partner didn't ZERO the balance when weighing the baking soda in the weighing boat. Would this cause you bag to be overfilled or under filled or would it have no effect? Explain.
4. Your partner grabbed the wrong acid from a stock bottle labeled 12M. Would this cause you bag to be overfilled or under filled or would it have no effect? Explain.
5. Your partner placed the bag on top of his cell phone as the reaction progressed. The phone battery began to malfunction and heated up. Would this cause you bag to be overfilled or under filled or would it have no effect? Explain.

B. <u>DISCUSSION OF ERROR</u>

VII. CONCLUSION