Objective: Your objective is to use stoichiometric calculations to inflate the Ziploc bag provided with the optimal amount carbon dioxide.

The development of the airbag for automobiles required the combined efforts of both chemists and engineers. The basic idea is simple: in the event of a collision, a plastic bag rapidly inflates with a gas, preventing the occupant from hitting the dashboard or the steering column. There are still some unresolved issues regarding the use of airbags and the type of air bag that provides the most safety. With regard to the bag itself, it must:

1. Not inflate by accident.
2. Produce non-toxic materials.
3. Produce a gas that is cool.
4. Inflate very rapidly (20-60 milliseconds).
5. Be lightweight, easy to handle, and stable for long periods.

The chemical reaction that occurs in most air bag systems is the decomposition of sodium azide (NaN₃), producing nitrogen, an extremely unreactive gas.

1. Write the reaction for the decomposition of Sodium Azide below:

In this lab, since sodium azide is extremely toxic (it is a carcinogen as well as a skin and eye irritant) you will use another gas-producing reaction to construct your airbag. You and your team will design and test your own airbag system by combining sodium bicarbonate and acetic acid (HC₂H₃O₂...otherwise known as vinegar) in re-closeable ziploc bags. Carbon dioxide, water, and sodium acetate are the products of this reaction.

2. Write the chemical equation for the reaction described above and then balance the equation.

3. Which product do you think will be the gas that will inflate your airbag?
Fill in the table based on the bag you use and the conditions in the classroom the day you do the lab.

<table>
<thead>
<tr>
<th>Air Temperature (K)</th>
<th>Pressure in room (Atm)</th>
<th>R (L Atm) (mol K)</th>
<th>Volume of bag (L)</th>
<th>Moles of gas needed from calculation</th>
</tr>
</thead>
</table>

4. What volume of gas do you need to fill the bag? (Fill the bag with water and then measure the volume in a graduated cylinder. Record your results in the table.)

5. How many moles of gas do you need to fill the bag? Use $PV = nRT$

6. Using the moles of gas needed and the mole ratio of the balanced equation, calculate the mass of NaHCO$_3$ needed to react and produce the needed volume of CO$_2$. Use **Dimensional Analysis.**

   __ moles of CO$_2$ / __ / __ / = __ g NaHCO$_3$

Stop and check your answer with your teacher

Materials:
Each group will be given the following materials—**no more, no less**, which should be enough for 1 air bag design: 5.0 g sodium bicarbonate, 25 mL 1M acetic acid, 1 graduated cylinder, and 1 plastic sandwich baggie. Mass balances are available at the back of the classroom.

Procedure:
Determine your own procedure and record in your Lab Report.

Notes:
Based on stoichiometric calculations, calculate the amounts of acid and sodium bicarbonate you would need to react to fully inflate the bag. In other words, what is the most CO$_2$ you can generate to fill the bag, but not have it pop open? The following information will be useful:

1. You will need to get the volume of the bag. Create your own plan to do this.
2. Acetic Acid is a 1M solution of acetic acid (HC$_2$H$_3$O$_2$) in water. You will use 25 ml, (0.025 liters) of vinegar. The vinegar will be an excess reagent.

Once you determine how to make the most efficient air bag get an approval from your teacher to start building your prototype and final air bag.