Planning Lab: Design an Air Bag

A knowledge of gas properties and chemical reactions is directly applicable to technologies like rockets and air bags.

In modern automobiles, a crash prevention safety feature is the air bag. Contrary to what most people believe, which is that the gas comes from a compressed air tank, these air bags are filled with a gas which results from a rapid chemical reaction.

Most air bags in automobiles are inflated with nitrogen gas produced by the rapid chemical reaction of sodium azide with iron (III) oxide ...

$$6\ NaN_{3(s)} \ + \ Fe_2O_{3(s)} \longrightarrow 3\ Na_2O_{(s)} \ + \ 2\ Fe_{(s)} \ + \ 9\ N_{2(g)}$$

(FYI: The azide ion is N_3^{-1}. The reaction is triggered by an electric current initiated by the impact sensor. The reason why nitrogen gas is chosen is that $N_{2(g)}$ has a lower molar mass, thus high molecular velocity, hence enabling the gas to inflate the bag as rapidly as possible.)

In this problem, you will be simulating this process through another chemical reaction; your air bag will be a zip-lock type plastic bag.

Your task is to use baking soda, $NaHCO_{3(s)}$, and 0.50 mol dm^{-3} $HCl_{(aq)}$ to generate a gas that will help to ***just fill*** a small zip-lock plastic bag. The ideal result will be to fill the bag to plumpness, not to overinflate or underinflate the bag; the bag may also contain unreacted chemicals and/or other products of the reaction.

Design a procedure using appropriate apparatus, materials,including the masses and amounts needed . Your procedure must take into account of suitable quantities, concentrations and safety concerns.

You ***must write*** your procedures in your lab book and obtain my approval before starting the experiment. I will prohibit any procedure I deem to be dangerous. Time will be saved if you show me your procedure ***before*** you come to the lab. Your procedure must allow you to collect sufficient relevant data to generate sufficient gas to inflate the zip-lock bag. Design a suitable data table to include units and uncertainties.

Planning, Data Collection and Data Evaluation should be important aspects of your report.

Prelab Assignment

1. a) How many grams of sodium azide are required to inflate an air bag with nitrogen gas to a volume of 46.0 L at 25 ^{O}C and a pressure of 103.3 kPa, according to the following equation:

$$6\ NaN_{3(s)} \ + \ Fe_2O_{3(s)} \longrightarrow 3\ Na_2O_{(s)} \ + \ 2\ Fe_{(s)} \ + \ 9\ N_{2(g)}$$

b) How would the amount of sodium azide needed to inflate an air bag to a volume of 46.0 L depend on the altitude, say, driving along the Rocky mountains: more, less, the same, won't work? Explain.

2. Lead (II) azide, $Pb(N_3)_2$, is used in warning detonators for trains. In an emergency, disks containing lead(II) azide are placed on the track. The slightest pressure of the engine wheels causes the lead(II) azide to explode, and the noise warns the engineer of trouble ahead. Write a balanced equation for the decomposition of lead(II) azide. Describe why you think sodium azide, and not lead(II) azide, is used for air bags. Provide supporting evidence for your opinion.