Applying Green Chemistry to Purification Lab

Name _________________________________  
AP Chemistry

Objective:  
The goals of this lab are to:  
- Design a procedure to separate two substances using the principles of green chemistry.  
- Assess the quality of a lab report submitted for peer review before being published.

Background:  
What chemists do is design chemicals and chemical processes. These practices involve a few main principles. One of these is that pure substances have unique properties that can be used to distinguish them from one another. A second principle is that chemists consider the benefits and risks of different options when deciding which is the best chemical process. These two principles form the focus of this experiment.

In addition, the 12 Principles of green chemistry are considered in the purification of a mixture. Specifically, Principle 2, Nothing should be left over, is used as a guideline when it comes to making decisions about chemical processes. Atom economy is introduced as a means to compare processes in terms of how much is left over.

Materials  
A mixture of sodium bicarbonate and sodium carbonate  
crucible and cover  
weighing paper  
scoopula  
Bunsen burner (hot plate)  
ring stand  
wire gauze  
electronic scale  
tongs

Pre Lab Activity  
1) What is a substance? What is a mixture? How are they related?

2) What are the general characteristics of substances chemists use to separate mixtures into individual substances?

3) Define percent yield and atom economy.

4) How are these two methods of measuring efficiency of a reaction the same? How do they differ?

5) When sodium bicarbonate is heated it decomposes to form sodium carbonate, carbon dioxide gas and water vapor. Write the balanced chemical equation for this reaction.

6) You will be given a mixture of sodium bicarbonate and sodium carbonate and asked to determine the % of each in the mixture using the unique properties of the substances. Because sodium bicarbonate decomposes when heated to form sodium carbonate could this be used to separate the two? Explain.

7) If a 4.473 g is heated to a final mass of 3.057g how much mass was lost and what does this mass represent?
Procedure

Design a procedure that will determine the relative amounts of NaHCO$_3$ and Na$_2$CO$_3$ in a mixture of the two substances using the 12 principles of green chemistry and stoichiometry.

Show your proposed procedure to your teacher before attempting the experiment.

You may use all of the equipment and chemicals listed above and if any additional equipment is needed inform your instructor.

Data

Create your own data table from the procedure above. Make sure to include a title for this table.

Calculations

1. Determine the relative amounts of NaHCO$_3$ and Na$_2$CO$_3$ in your sample.

Conclusion and Analysis

1. How many times did you heat your mixture and for how long?
2. How did you apply the principles of green chemistry to your lab procedure?
3. Atom economy is a means to measure how “green” a process is. Atom economy equals = mass of desired product/mass of total product.

Calculate the atom economy for the decomposition of sodium bicarbonate assuming the desired product was sodium carbonate.

4. Sodium carbonate is produced commercially from brine from the overall process:

   \[ 2 \text{NaCl} + \text{CaCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CaCl}_2 \]

Which process is greener, has the highest atom economy?