Lab: Carbonate Identification

FOR THE TEACHER

Summary
In this lab students use gas laws and stoichiometry, along with some balloons and simple measuring tools, to identify a metal carbonate from a short list of possibilities.

Grade Level
High School

AP Chemistry Curriculum Framework
This lab supports the following units, topics and learning objectives:

- **Unit 1: Atomic Structure and Properties**
  - **Topic 1.1:** Moles and Molar Mass
    - SPQ-1.A: Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.
  - **Topic 1.3:** Elemental Composition of Pure Substances
    - SPQ-2.A: Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.

- **Unit 3: Intermolecular Forces and Properties**
  - **Topic 3.4:** Ideal Gas Law
    - SAP-7.A: Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law.

- **Unit 4: Chemical Reactions**
  - **Topic 4.1:** Introduction for Reactions
    - TRA-1.A: Identify evidence of chemical and physical changes in matter.
  - **Topic 4.2:** Net Ionic Equations
    - TRA-1.B: Represent changes in matter with a balanced chemical or net ionic equation:
      a. For physical changes.
      b. For given information about the identity of the reactants and/or product.
      c. For ions in a given chemical reaction.
  - **Topic 4.5:** Stoichiometry
    - SPQ-4.A: Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.

Objectives
By the end of this lab, students should be able to
- Write chemical equations, and correctly predict products for the reaction between potential carbonate compounds and an acid.
- Design a reliable experiment to collect carbon dioxide produced in a reaction, as well as to quantify it to use in stoichiometric calculations.
- Identify an unknown based on results of their experiment and thorough analysis.
Chemistry Topics
This lab supports students’ understanding of
- Identifying an unknown
- Gas Laws
- Chemical Reactions
- Stoichiometry

Time
Teacher Preparation: 10 minutes
Lesson: 60 minutes

Materials
(* indicates materials supplied by teacher)
- 3 balloons, equal size*
- 1 length of string about 30 cm in length*
- 1-2 plastic test tubes or culture tubes*
- 3 measured samples of the carbonate*
- Scissors
- Measuring spoons
- Ruler with mm markings

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.

Teacher Notes
- I use this lab experiment as a take home lab assignment. Find out more about my take home labs in the March issue of Chemistry Solutions or in the AACT Webinar archive.
- This particular lab is used with my AP students as a summary review of recent material. I try to design these labs so that they offer experimental design and a little bit of research on new material,
- The materials are commonly found at home, so have students to check for availability. If this is difficult, allowing students to complete the lab in the classroom before or after school is a good option. Note that in this particular lab, several items from the material list will be supplied by the teacher.
- This lab was adapted from the 2008 US National Chemistry Olympiad Exam—Part III
FOR THE STUDENT

Lesson

Carbonate Identification

Background
When a person finds a rock sample of unknown composition he or she can perform various tests to verify the presence of or prove the absence of certain chemicals. One of these tests is a test with acids, where the scientist uses a sample of an acid, such as HCl and puts it on a sample of the rock to see if it produces bubbles. The production of bubbles will be an indicator that the carbonate ion, \( \text{CO}_3^{2-} \), is present. Carbonate ions are also present in many water supplies and will react with metal ions to form precipitates or build-up called “scale.” This “scale” build-up causes constriction in pipes and can restrict water flow or ruin the heating elements in electric hot water heaters.

Problem
You are given a 0.35 g sample of an unknown metal carbonate, \( \text{M}_x\text{CO}_3 \), and can react it with white vinegar, which is approximately 0.90M in acetic acid \( \text{HC}_2\text{H}_3\text{O}_2 \) (aq) along with materials listed. The metal carbonate contains either Mg, Ca, Li, or Na. Based on the available chemicals and materials address the tasks and questions that follow.

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.

Materials
(* indicates materials supplied by teacher)
- 3 balloons, equal size*
- 1 length of string about 30 cm in length*
- 1-2 plastic test tubes or culture tubes*
- 3 measured samples of the carbonate*
- Scissors
- Measuring spoons
- Ruler with mm markings

Exploration
Design an experiment, with multiple trials, that will allow you to collect the data necessary to identify the metal carbonate which you have been given. Information that you might find useful includes:
- You may assume 1atm of pressure
- You should check your thermostat for temperature reading, you will need to find out how to convert it.
- A teaspoon measures approximately 5 ml.
- A tablespoon measure approximately 15 ml.

The data you collect should be both qualitative and quantitative. Qualitative data can include both anecdotal evidence and pictures.
Data
Use the data table below as a guide.

<table>
<thead>
<tr>
<th>Factor being measured</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of Carbonate</td>
<td>0.35 g</td>
<td>0.35 g</td>
<td>0.35 g</td>
</tr>
</tbody>
</table>

Research Questions & Calculations
1. Write a chemical equation for the general reactions between the each of the potential carbonates and the acetic acid (you may assume a 1:1 mol ratio for the $M_xCO_3 : CO_2$).
2. Prepare a data table for recording your data and observations; use the data table above as a guide.
3. Explain how you decided how much vinegar to use for the experiment.
4. List the steps of your procedure for the experiment.
5. Show the set up/work for finding moles of gas collected.
6. Show the set up/work for the calculation of the molar mass of $M_xCO_3$
7. Based on your results, identify the metal carbonate from the list provided.
8. Using your data and calculations justify your choice of metal carbonate.
9. Discuss at least 3 possible sources of error that could manifest themselves when using such a method and how, specifically, the errors you listed would affect the calculated molar mass of the carbonate.

Parent Signature ____________________________________   Date _____________