Lab: Fizzy Drink

FOR THE TEACHER

Summary
In this lab, students will learn the properties of acid and bases while applying the principles of stoichiometry to calculate the amount of base needed to neutralize an acid completely and produce a bubbly drink.

Grade Level
High School

Objectives
By the end of this lab, students should be able to
- Determine which substance is an acid and which substance is a base.
- Calculate the amount of base needed to react with, and neutralize, a given amount of acid.

Chemistry Topics
This lab supports students’ understanding of
- Acid & Bases
- Acid-Base reactions
- Chemical reactions
- Stoichiometry
- Limiting reactants

Time
Teacher Preparation: 10 minutes
Lesson: 45 minutes

Materials
- Note: All materials need to be food safe!
- 3 oz. Dixie cups, 1 per student and 1 extra per lab group
- Kool-Aid or Hawaiian punch, 2 gallons is more than enough for 90 students
- Spoon to scoop chemicals (one per substance cup)
- 2 or more Balances (one with substance A and one with substance B, the more that are available will lower the wait time)
- Baking Soda = Substance A, sodium bicarbonate, one box is more than enough
- Citric Acid = Substance B, citric acid, it can be found in the canning area of the grocery store. Each group needs less than 1 gram.
- Weigh boats or cupcake liners

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.
- Do not consume lab solutions, even if they’re otherwise edible products. Use teacher discretion, or perform outside the lab setting.
- Food in the lab should be considered a chemical not for consumption. Use teacher discretion, or perform outside the lab setting.
Teacher Notes

- Please note that the teacher preparation time will be longer if you need to purchase a lot of the individual materials.
- I have students work in groups of 3-4.
- For scoops for the chemicals, you can use plastic spoons. You can also use large Popsicle sticks. Since students will consume the drink, you need to make sure everything is food safe.
- The lab should be performed outside the lab setting or in the hallway to make sure everything stays food safe. If this isn’t an option, you could thoroughly clean your lab tables and then cover them in butcher paper or table cloths.
- I do this lab in the Acid-Base unit. It brings stoichiometry back so students have to review and maybe revisit their notes. Other teachers have done it in the stoichiometry unit. If done in the stoichiometry unit, students may have to look up properties of acid and bases such as taste.
- This activity can be scaled back to elementary or middle school by only doing part A as an intro to acid base properties. In the pre-lab, question 2, the skeleton equation could be given to lower the level of rigor.

- Pre-Lab Question Answers
  1) Citric Acid Molar mass = 192.12 g/mol
  2) $\text{H}_3\text{C}_6\text{H}_5\text{O}_7 + 3\text{NaHCO}_3 \rightarrow \text{Na}_3\text{C}_6\text{H}_5\text{O}_7 + 3\text{H}_2\text{O} + 3\text{CO}_2$
  3) 0.66g NaHCO₃
  4) Acids = less than 7 Bases = more than 7
  5) Acids= sour Bases = bitter

- Calculation Answer: For 0.30 grams of citric acid, students should use 0.39 grams of baking soda

- Analysis Question Answers
  1) 0.156 moles of CO₂
  2) No they both would not be used completely up. Citric acid and baking soda have different molar masses and different mole ratios.
  3) No it is not correct. They have a mole ratio of 1:3, if Randy had 1 mole of citric acid and 3 moles of baking soda then it would be correct. Since both substances have different molar masses it does not translate to 1:3 gram ratio.

FOR THE STUDENT

Lesson

Fizzy Drink Lab

Background

The first man-made non-alcoholic carbonated beverage is attributed to Joseph Priestley who accomplished the feat in 1767 (Priestly, 1772). He used chalk (calcium carbonate) and sulfuric acid to produce carbon dioxide which was bubbled into water. Carbonated beverages had been produced before this time, but the process used sugar and yeast to yield carbon dioxide and alcohol through fermentation. Many different non-alcoholic carbonated beverages have been created since including colas, phosphates, root beers, ginger ales, tonic waters, seltzer waters, and others.

This activity uses citric acid and baking soda to produce the fizz in a beverage. Citric acid, $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$, is a triprotic acid with $pK_a$ values ranging from 3 to 6.4. It is highly soluble and often used in beverages to enhance flavor and add a pleasant sour fruity taste. Baking soda (NaHCO₃) is a white powder also known as sodium bicarbonate, bicarbonate of soda, sodium hydrogen carbonate, or sodium acid carbonate. The chemical and physical properties of baking soda afford it a wide range of applications, including cleaning,
deodorizing, buffering, and fire extinguishing. A mole of baking soda will react with an acid to produce a mole of carbon dioxide.

**Pre-lab Questions**

1. What is the molar mass of citric acid, \( \text{H}_3\text{C}_6\text{H}_5\text{O}_7 \)?

2. Write the balanced chemical equation for the following reaction:

\[
\text{Citric acid} + \text{baking soda} \rightarrow \text{sodium citrate} + \text{water} + \text{carbon dioxide}
\]

3. If you have 0.50 grams of citric acid, how many grams of baking soda will be needed to react with all the citric acid?

4. a. What pH do acids have?  
   b. What pH do bases have?

5. a. How do acids taste?  
   b. How do bases taste?

**Problem**

- Given two substances, A and B, determine which is the acid and which is the base.
- You will be given exactly 0.30 grams of citric acid. You need to calculate how many grams of baking soda (\( \text{NaHCO}_3 \)) should be added to make a fizzy Kool-Aid® drink that is “just right.”

**Materials**

- Kool-Aid or Hawaiian Punch  
- 3 oz. Dixie cups (1 per person plus 1 to get the drink)  
- Plastic spoon  
- Balance  
- Substance A  
- Substance B

**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 clean-up of materials and disposal of any chemicals.  
- Do not consume lab solutions, even if they’re otherwise edible products. Therefore the lab will be performed outside the lab.  
- Food in the lab should be considered a chemical not for consumption. Therefore the lab will be performed outside the lab.
**Procedure**

**Part A:**
1. Fill a Dixie cup with Kool-Aid®. Divide the drink among all group members. Taste the plain Kool-Aid® and record observations and taste in the data table.
2. Fill a Dixie cup with Kool-Aid®. Add 0.5 grams of substance A. Divide the drink among all group members. Taste the mixture and record observations and taste in the data table.
3. Fill a Dixie cup with Kool-Aid®. Add 0.5 grams of substance B. Divide the drink among all group members. Taste the mixture and record observations and taste in the data table.
4. Determine which substance is citric acid and which is baking soda based on your observations and taste testing.
5. Calculate below how much baking soda is needed to react with 0.3g citric acid and begin part B. (*Make sure you show your work in the calculation section below.*)

**Part B:**
1. Fill a Dixie cup with Kool-Aid®. Pour the Kool-Aid® from the Dixie cup into a larger cup (to prevent bubble-over of mixture).
2. Now add 0.30g of citric acid (H$_3$C$_6$H$_5$O$_7$) and your calculated amount of baking soda (NaHCO$_3$) in the recipe above to the Kool-Aid®.
3. Divide the drink among all group members. Taste the mixture and record observations and taste in the Part B data table.

**Data**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Part A</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Trial</strong></td>
<td><strong>Ingredients</strong></td>
<td><strong>Observations</strong></td>
<td><strong>Taste</strong></td>
</tr>
<tr>
<td>1.</td>
<td>¼ Dixie cupful Kool-Aid®</td>
<td></td>
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<tr>
<td>2.</td>
<td>¼ Dixie cupful of Kool-Aid® + 0.5 g substance A</td>
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<tr>
<td>3.</td>
<td>¼ Dixie cupful of Kool-Aid® + 0.5 g substance B</td>
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<table>
<thead>
<tr>
<th><strong>Substance A Identity:</strong></th>
<th><strong>Acid or Base?</strong></th>
<th><strong>Substance B Identity:</strong></th>
<th><strong>Acid or Base?</strong></th>
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<tr>
<th><strong>Part B</strong></th>
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<tbody>
<tr>
<td><strong>Ingredients</strong></td>
<td><strong>Observations</strong></td>
<td><strong>Taste</strong></td>
</tr>
<tr>
<td>Kool-Aid® + mixture of A and B</td>
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Calculations
You will be given exactly 0.30 grams of citric acid. You need to calculate how many grams of baking soda (NaHCO₃) should be added to make a fizzy Kool-Aid® drink that is “just right”.

0.30g citric acid and __________g NaHCO₃

Analysis
1. If you have 10.0 grams of citric acid with enough baking soda (NaHCO₃) how many moles of carbon dioxide can you produce?

2. If you mixed 10 grams of each reactant in a container, would both of them be used up completely? How do you know?

3. The mole ratio of citric acid (H₃C₆H₅O₇) to baking soda (NaHCO₃) is 1:3. Randy wants to add 1 gram of citric acid to 3 grams of baking soda. Is this correct? Why or why not.

Conclusion
Write a short conclusion paragraph explaining which substance was the acid and which substance was the base. Explain how you knew which was which. Explain how much base you needed to react with the 0.3g of citric acid and how you calculated this amount. Finally, describe how your final drink tasted and any observations.