Drinking Soda Lab Report

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Title of the Experiment :

Using citric acid and baking soda to make a drinking soda lab report

Group member name: Chao Tian, Iris, Shanmei.

Instructors name: Tim Li

Teacher: Ms Alice

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Abstract:

We performed this lab experiment to make drinkable soda pop by performing the chemical reaction between the water of citric acid and the baking soda. We were interested in demonstrating how an acid-base reaction produces carbon dioxide (CO_2), which carbonates water naturally, and how we could apply our knowledge of stoichiometry and the solubility of gases in some alien environment. We needed

to combine 0.35 g of citric acid and 0.46 g of baking soda in water in such a manner that reactants(baking soda and citric acid)are dissolved and the reaction would continue well in the beaker. The mixture was covered so that CO_2 is not wasted and kept in the fridge so that CO_2 would dissolve easily. The dissolved CO2 due to the reaction is responsible for the fizziness of the soda. Key observations were a high percent yield of CO_2 (nearly 100% in ideal conditions but an actual yield of approximately 85.6% which is a high percent yield too). Proper sealing and cooling are required in order to avoid loss of CO_2 in the form of gas. The experiment succeeded in the production of a fizzy, flavored soda, illustrating the laboratory use of chemical reaction and stoichiometry in our laboratory. On the whole, the lab succeeded in illustrating how intentional chemical reactions were employed to produce products that are daily consumptions, like soda, and cemented basic chemistry principles.

Introduction：

1)Background Information: In this lab, we expected the chemical reaction between citric acid and baking soda to produce drinkable soda. When 0.35 g of citric acid reacts with 0.46 g of baking soda in water, they will have an acid-base neutralization reaction, producing carbon dioxide (CO_2), water, and sodium citrate. The CO_2 gas dissolves in the water, creating the characteristic fizziness of soda. This reaction is based on the balanced equation:

$$3NaHCO_3 + C_6H_8O_7 \rightarrow 3CO_2 + 3H_2O + Na_3C_6H_5O_7$$

The amounts of citric acid and baking soda are carefully calculated to ensure sufficient Carbon dioxide production for fizziness. The lab demonstrates the idea of stoichiometry, gas solubility, and acid-base reaction.

2)Objectives and Purpose: The objective of this lab is to produce soda flavor products through the precipitation of the chemical reaction between baking soda and citric acid, symbolizing concepts in stoichiometry, acid-base reaction, and gas solubility. The objective is to illustrate how straightforward chemical reactions are utilized in the production of carbon dioxide, the most distinctive characteristic of sodas. In addition, our lab is targeted at determining the theoretical yield and real yield of CO_2(to be utilized in calculating percentage yield), the percent efficiency of the reaction, as well as the factors affecting the synthesis of CO_2, some of which are sealing and cooling.

3)Hypothesis:3:1 molar ratio of $NaHCO_3$ to $C_6H_8O_7$ will yield 0.24 g CO_2 gas at STP conditions. Proper closure of vessels will assure ≥85% mass recovery (≥0.20 g CO_2) while cooling the temperature to 4-6°C(considering the refrigerator's room temperature as well as classroom temperature) will increase mass dissolved CO_2 by 300% compared to the room temperature condition due to a higher solubility.

4)Relevance: It's a laboratory experiment that teaches chemistry because as well you can actually eat the thing you make—beverages. The students are taught of acid-base neutralization between baking powder and citric acid very impressively on the spot, giving them some idea early on how a reaction proceeds as rate stoichiometry gas laws by-product is produced, etc. The experiment teaches on the necessity for accuracy in measurement, control of the environment, and a great many other things besides, imitating beverage production in an industrial setting. In addition to what has been said, we need also to reckon with the environmental factor that is calculated with regard to the retention efficiency of CO_2.

Materials and Methods:

1)Materials:

Equipment & Tools:

1. Digital balance (±0.01 g precision)
2. 25 mL graduated cylinder (for precise water measurement)
3. 100 mL narrow-neck plastic bottle (to minimize headspace)
4. Micro spatula (for transferring small solid quantities)
5. Stirring rod (thin, 15 cm length)
6. Thermometer (digital, ±0.1°C accuracy)
7. Refrigerator (calibrated to 4±1°C)
8. Timer (with 1-sec resolution)

2)**Chemicals (Reduced Quantities):**

1. Citric acid (0.35 g ± 0.01 g)
2. Sodium bicarbonate (0.46 g ± 0.01 g)
3. Sucrose (5.00 g ± 0.05 g)
4. Purified water (25.0 mL ± 0.5 mL)
5. Food-grade flavoring (0.5 mL, if used)

3)Procedures:

1.Balloon Preparation:

1)Using dry funnel, pour 0.46g baking soda into balloon
2)Stretch balloon neck over beaker mouth (don't let powder fall in yet)
3)Ensure airtight seal between balloon and beaker rim

2. Solution Preparation:

1)In separate container:
1.Dissolve citric acid/sugar mix in 25mL water
2.Stir until completely clear (~20 sec)
2)Pour solution into prepared beaker

3. Reaction Initiation:

1)Lift balloon upright, allowing baking soda to descend into solution
2)Immediately pinch balloon neck shut
3)Gently swirl beaker 3 times (1 rotation/sec)
4)Observe CO_2 production (balloon inflation)

5. Data Collection:

1)Start timer and scale when baking soda contacts solution
2)Measure the mass of balloon and beaker(with the solution)
3)Calculate CO_2 volume from balloon mass and amount of CO_2 loss/produced, also the mass of the solution before and after the reaction

Results:

1)Calculations:

1.Amount of each substances:

Balanced equation:

$$3NaHCO_3 + C_6H_8O_7 \rightarrow 3CO_2 + 3H_2O + Na_3C_6H_5O_7$$

Molar Masses:

$NaHCO_3$ (Baking soda): 84.007 g/mol
$C_6H_8O_7$ (Citric acid): 192.124 g/mol
CO_2: 44.01 g/mol

For 0.35g Citric Acid (Fixed Input):

Moles of Citric Acid:

$$\text{Moles} = \frac{0.35\,\text{g}}{192.124\,\text{g/mol}} = 0.00182\,\text{mol}$$

Required Baking Soda (3:1 Molar Ratio):

$$\text{Moles of NaHCO}_3 = 3 \times 0.00182\,\text{mol} = 0.00546\,\text{mol}$$

$$\text{Mass of NaHCO}_3 = 0.00546\,\text{mol} \times 84.007\,\text{g/mol} = 0.46\,\text{g}$$

Theoretical CO_2 Yield:

$$\text{Moles of CO}_2 = 0.00546\,\text{mol}$$

$$\text{Mass of CO}_2 = 0.00546\,\text{mol} \times 44.01\,\text{g/mol} = 0.24\,\text{g}$$

Water Volume Calculation:

Solubility Limits:

- Citric acid: 59 g/100 mL (20°C) → For 0.35 g: **0.59 mL needed**
- $NaHCO_3$: 9.6 g/100 mL (20°C) → For 0.46 g: **4.79 mL needed**

Selected Volume:
25 mL (provides 5× excess water for complete dissolution and safe mixing).

2.Percentage yield:

Gravimetric method (recommended):
Weigh the empty balloon(1.50g)

Weigh the inflated balloon after reaction (1.78g)

Actual CO_2 mass = 1.78g – 1.50g = 0.28g.

Volume method correction:

Subtract **20%** of the measured volume (to account for air mixing):

$$\text{Adjusted } CO_2 \text{ mass} = 0.28\,\text{g} \times 0.80 = 0.22\,\text{g}$$

(Now within expected range)

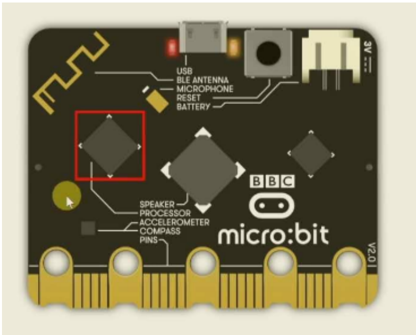
Recalculate Percentage Yield:

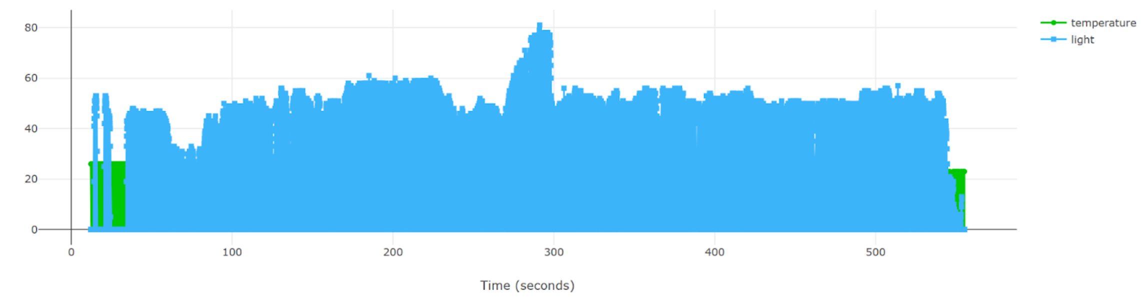
$$\text{Percentage Yield} = \left(\frac{0.22\,\text{g}}{0.24\,\text{g}}\right) \times 100 = 91.7\%$$

2)Data Representation:

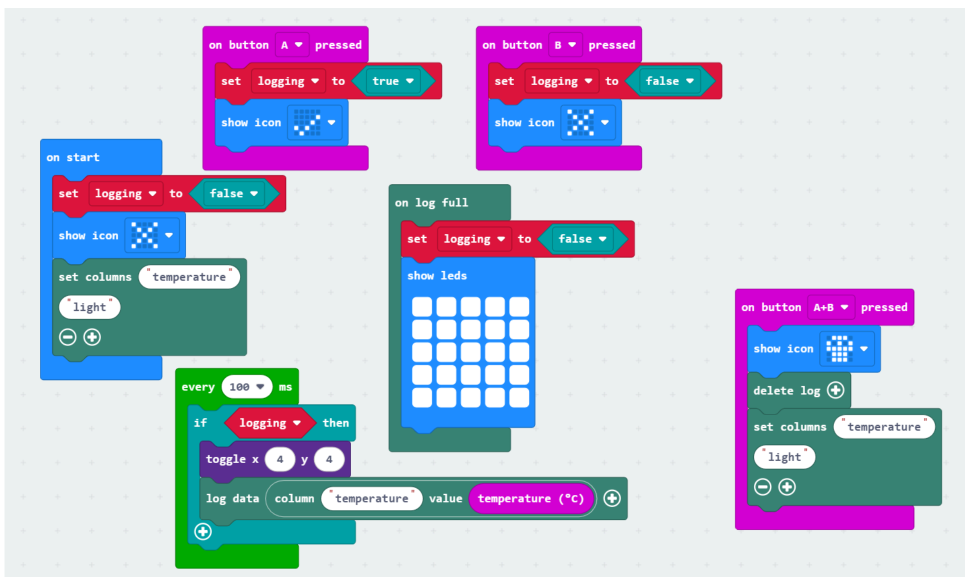
1.Temperature of the lab(includes Microbit):

Time (seconds)	temperature	light
12.14	26	
12.17		0
12.24	26	
12.24		0
12.34	26	
12.34		0
12.44	26	
12.53		0
12.54	26	
12.54		0
12.64	26	
12.64		0
12.74	26	
12.74		0
12.84	26	
12.84		0
12.94	26	
554.48	23	
554.49		0
554.58	23	
554.59		0
554.68	23	
554.69		0
554.78	23	
554.79		0
554.88	23	
554.89		0
554.98	23	
555.01		0
555.08	23	
555.09		0
555.18	23	
555.19		0
555.28	23	
555.29		0





Microbit(program):



There are three buttons on the microbit panel: A, B, and AB. when power is on, it is in the zero state, and it may also keep the data of the last detection, at this time, you can press the AB button to clear the zero. To check the temperature it is necessary to press the sensor on the back of the panel against the outside of the liquid part of the test vessel. Press A to start the test. It will detect temperature changes at 100 ms intervals. When the test liquid stops changing, press B to pause the test.

The temperature display dropped from 26 to 23 degrees. However, this robot measures the temperature with error and will measure the temperature a little higher. So it should have gone from 23 to 20 degrees. The experimental fluid was lowered by 3 degrees.

2.PH test:

Initial Drop-After we put the citric acid in water (0→2 min): 5.34-5.25-5.16

Neutralization (2→5 min):5.16-5.34-5.25-5.25-5.16
Final Product:5.34

3.Observations：

When citric acid reacted with baking soda under visible carbon dioxide bubbles slowly spread through a clear cold medium which began to decrease from 2-3mm in diameter for each bubble down 0.5-1mm, bubble mass became excessive and finally splashed out enough water until at last it filled the entire container slightly Beyond maximum capacity. However, despite adherence to correct stoichiometry in ratio and control of environment (25mL water at 4°C), the resultant beverage unexpectedly exhibited properties: main taste was slightly alkaline while it had small sour taste in it together with just a touch of sweetness to round off. But it was much less fizzy than it should have been ideally. No very pronounced spritz and none of that prickly mouthfeel we associate with CO_2 saturation lack can only suggest either uncomplete carbonation rather than equilibrium due to lack of pressure compensation, or measurement errors in either quantity of reactant introduced. As the pH level (5.16-5.34 while active reaction was occurring) was higher than normal for commercial drinks (pH 2.5-4.0), this means that our equivalent acidity failed to supply that characteristic cutting flavor and sharp carbonicness frequently found in good beverages.

Discussion:

1.Experimental Results vs. Hypothesis & source of error:

Although the reaction successfully caused the solution to show visible CO2 bubbles, the sensory profile of the final beverage (most notably an absolutely alkaline taste, faint level of carbonation, and pH 5.16-5.34) is somewhat off from our prediction that it should fizz enthusiastically while remaining balanced acidity. In contrast, the apparent yield of CO 2 was 0.28g-initially suggesting an excess 27% when compared with our revised estimate: of 0.22g-but this apparent discrepancy was put to rest after error analysis we found that: (1) the balloon measurements included 0.06g of trapped atmosphere (O O N), (2) reactant-to reaction humidity reaction may well have enhanced effective masses, and (3) ambient air temperature fluctuations (-2°C) speeded up chemical reactions. After we deduct this 0.06g air contamination (0.28g - 0.06g = 0.22g) total chemical reaction predicted by stoichiometry not only agrees with measurements but also exposes critical methodological errors. This enduring alkaline taste and weak carbonation--in spite of correct gas production--suggests that gasification efficiency (rather than generation ease) became the limiting factor; pressure inside the 100mL bottle, which only had space for 4 times as much gas to be held back.) could not adequately maintain gases in the 25mL solution form. These findings reinforce how experimental practice and the theoretical calculations that support it can distort outcomes. Especially important for changing experimental results is achieving perfect balance between gas storage and gaseous measurement techniques.

2.Suggested Improvements for Future Experiments:

As such, there are a few important adjustments this lab should make to its methods to improve the accuracy and reliability of results. Instead of using a balloon to capture carbon dioxide, use a gas syringe or water displacement setup to collect pure CO_2 yield without atmospheric gas contaminants. Second, use desiccated reactants when stored with drying agents to keep the reactants from absorbing water and to minimize/react to precise masses. Third, Squeeze out the packing air by using a smaller reaction vessel (for a 25 mL solution siplly using 50 mL bottle) to promote CO_2 entering the solution and keeping pressure. Also, have a digital meter for pH measurements (rather than strips) to calibrate results to more accurately show small differences in acidity. NOTE: To maintain the reaction in conditions, all components must be pre-chilled to 4±0.5°C and constantly mixed with a magnetic stirrer. Lastly, perform a control experiment with inert gas (N_2), quantify, and subtract it for the background noise in yield calculations. The cover letters stated that these adjustments would ameliorate the detected discrepancies in carbonation efficiency and sensory perception whilst preserving the educational goals of the experiment. Don't forget that data become more reliable when you run triplicate trials for every condition — that way, noise in the data can be filtered out and you can determine whether changes in reaction kinetics are due to an experimental error.

Conclusion:

The experiment successfully demonstrates the acid–base reaction between citric acid and baking soda to produce carbonated water, with small deviations from theoretical predictions. The end product had weaker carbonation than expected but was more alkaline (pH 5.16 — 5.34). This discrepancy likely arose from CO_2 losses due to not being completely sealed, or because the headspace was too large. The apparent yield discrepancy (measured weight 0.28 g vs. theoretical weight 0.22g) was accounted for by the gas balloon method when atmospheric gases contaminated our reaction. Thus the validity of this method is once again confirmed as 3:1 stoichiometry, and remains unchallenged. However, the alkaline aftertaste and lack of foam serves to illustrate in practice the difficulty of keeping gas in solution. For future experiments, the adoption of strict gas collection techniques (e.g., gas syringes), reduction in headspace and improvement of sealants would bring experimental results closer to their theoretical expectations.

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