What the Fizz?!

OBJECTIVES

The learner will be able to:

- Calculate the correct molar ratios of substances in a chemical reaction.
- The learner will calculate the mass of a particular compound formed from the masses of starting materials.
- The learner will apply principles of stoichiometry to food science.
- The learner will identify patterns in data and relate data to theoretical models.
- The learner will describe a reason for a given conclusion using evidence from an investigation.
- The learner will describe the difference between mass (grams) and moles.

PROBLEM / QUESTION

The purpose of this lab is to figure out how to make the best tasting fizzy drink, or suffer the consequences of bad math**!**

PRIOR KNOWLEDGE

Know how to:

- calculate a molar mass
- use molar mass as a conversion factor
- balance equations

Know:

- simple acid and base properties and neutralization
- observations indicative of a chemical change

P1. As prelab, read up on this website: http://www.oldtimecandy.com/fizzies.htm
Write a sentence or three to summarize what you find.

PREDICTIONS

P2. How could you use chemistry to successfully recreate this olde-time candy?

P3. Read through the materials list and Procedure 1. What safety rules are we breaking in this activity? Why is it acceptable for this lab?

SAFETY

- This lab involves food science. The utmost care should be taken that all food surfaces are clean and have not had contact with reagents.
- The products of this lab will be consumed; however, in any other situation chemicals should **NEVER** be taste-tested and food stuffs should not be brought into a laboratory.

MATERIALS

- Wax Paper
- Paper muffin cups
- Food beakers or large plastic cups
- Spoons
- 5 oz. mini cups
- Citric acid, $H_3C_6H_5O_7$
- Baking soda, $NaHCO_3$
- Sugar or sugar substitute
- Kool-aid
- Consumable water source
- Mass balance

BACKGROUND INFORMATION

- Use the wax paper to cover the balance and your workspace so that no trace materials on lab benches or balance pans contact any of the food materials. Make sure to tare the balance.
- Use the muffin cups as weigh boats to take the mass of substances safely.
- Make each solution in the beaker or large cup, then pour into mini cups to allow each group member to taste the solution without spit-swapping. You could even write your name on your cup.
- Take good care of your spoons! Don't let them rest on lab tables; rinse, dry, and reuse them as necessary.

PROCEDURE 1 – Try this!

1. Measure out 0.45 g of drink mix and 12 g of sugar into the container (beaker or cup).

2. Add about 200 – 250 mL cold water and stir to dissolve, this is the "starter solution".

3. Have a taste-test (using mini cups) and adjust sweetener if necessary. It should taste just like Kool-aid. **Taste a very small amount (less than 10%).**

4. Now, let's see what happens when we add the first ingredient, citric acid. Add approximately 3 grams to the container, dissolve, and taste-test. **Here, you may consume as much as you like.**

DATA AND OBSERVATIONS 1

5. Describe how your solution looks and tastes:

6. This solution contained an excess of citric acid. What are some characteristics of acids?

7. Dispose of the rest of your solution down the drain and rinse out your containers.

PROCEDURE 2 – Dare you to!

8. Try another: Remake the "starter solution" as you did in Procedure 1.

9. Add approximately 3 grams of baking soda. Dissolve it and taste-test **as much as you'd like.**

DATA AND OBSERVATIONS 2

10. Describe how your solution looks and tastes.

11. This solution contained an excess of baking soda, which is a base. What are some characteristics of bases?

12. What do you think happens when acids and bases react with each other?

13. Dispose of the rest of your solution down the drain and rinse out your containers.

PROCEDURE 3

14. Make another starter solution.

15. This time both the acid and base will be used. Choose **one** of the following recipes below to see if you can make a tasty beverage. Try and make a different combination than the groups nearby. **Circle** the one you will prepare:

1 gram citric acid + 1 gram baking soda (1:1)   1.5 grams citric acid + 0.5 grams baking soda (3:1)

0.5 grams citric acid + 1.5 grams baking soda (1:3) 1 gram citric acid + 0.5 grams baking soda (2:1)

DATA AND OBSERVATIONS 3

16. Now make your solution based on your chosen recipe. Record what you observe when the two solids are added to the solution:

17. What do you think is happening in the solution to cause this?

18. Describe how your solution looks and tastes. **Taste-test only a small amount; you will need to share with other groups.** Do you taste one of the ingredients more than the others?

19. Find at least 1 group that made a different recipe than yours and taste-test (try to find every combination). Make a table showing the combination and how the solutions look and taste:

20. Use your observations and describe why none of the combinations tasted like perfect Kool-aid.

21. Make a prediction of what should be added to each of the combinations to make it taste unlike the acid or base. Explain your choices.

22. Dispose of the rest of your solution down the drain and rinse out your containers.

PROCEDURE 4

Sometimes experienced recipes help when making foods. For example, to properly make a gravy, the fat to flour ratio by volume (in tablespoons) should be 1:1. To make a vinaigrette, the vinegar to oil ratio is usually 1:3 by volume.

23. If 3 tablespoons of vinegar are used, how much oil would you use to make a vinaigrette? Explain how you knew this.

24. Here is the equation/recipe for the reaction between citric acid and baking soda:

$$H_3C_6H_5O_7 + NaHCO_3 \rightarrow Na_3C_6H_5O_7 + H_2O + CO_2$$

25. Balance the equation in the space above, and rewrite your final answer below:

26. Using the balanced equation, decide what ratio the citric acid and baking soda should be added to make the perfect fizzy drink where all the citric acid reacts with all the baking soda. Explain your decision.

27. The ratio of the coefficients in the balanced equation matches one of the ratios that was made during Procedure 3, but it probably didn't taste very good (check your observations). If the ratio matches, why didn't it work?

28. Is there a unit we could use besides mass (grams) that would allow us to compare our experimental results to the balanced chemical equation? What is it?

29. If you used 0.90 g of $H_3C_6H_5O_7$, how many grams $NaHCO_3$ should you add to make the reaction work best and react completely? Show your work and explain.

Before continuing, raise your hand and get approval from the instructor:____

30. Make a starter solution, and add your calculated amounts.

DATA AND OBSERVATIONS 4

31. Describe how your solution looks and tastes:

32. How does the amount of fizz produced from this mixture compare to others that you have made? Why might this be?

33. Dispose of the rest of your solution down the drain and rinse out your containers. All paper/plastic products can be thrown away.

RESULTS AND ANALYSIS

Summarize your experiments and data in a table created by you and your lab partner.

DISCUSSION

- Write a paragraph that explains the solutions and reactions you made in this lab (the chemistry, what was going on?) You should write this explanation as you would explain your results to a freshman.
- Refer back to question 27. Why didn't our recipe ratios in grams work? Explain in detail.
- What evidence was there in the lab that a chemical reaction was taking place?
- What effects did changing the amounts of citric acid and baking soda have on the properties of your solutions, as well as the reaction? What effects would changing the amount of water in our procedure have on the results? Explain.
- If instead, we were baking chocolate chip cookies, which ingredients would ruin the taste of the cookies if you changed the amounts? Which could you change and still have delicious cookies?

GOING FURTHER

1. Using the following shapes to represent the chemicals and ratios in the balanced equation, draw a particulate representation of the chemical reaction for this experiment.

■ $H_3C_6H_5O_7$	○ $Na_3C_6H_5O_7$	▲ CO_2
□ $NaHCO_3$	● H_2O	

2. Calculate the molar masses of the particles. Does each of these particles have the same mass?

3. How does this help you relate the best tasting "formula" to the balanced chemical equation? Explain and show calculations to support your answer.

4. Which of the substances is responsible for the fizz? Look back at the recipes in Procedure 3. Which of the formulas should produce the least fizz? The most? Show calculations to support your answer.

5. Research the proper recipe to make ice cream from scratch (just vanilla will do). Copy the recipe as is, then turn it into a chemical equation, trying to use chemical formulas when possible, otherwise just use words. Make sure to balance your equation!

6. If we had 3072 teaspoons of sugar, how many cups of ice cream could be made?

REFERENCES

Adapted from Rohrig, Brian. (2000). Fizzy drinks: Stoichiometry you can taste. *Journal of Chem. Education*, 77(12) 1608A.