8D – DETERMINING LIMITING REACTANTS

INQUIRY

How can you produce the greatest amount of products without wasting any material?

MATERIALS

- Device with SPARKvue software
- Pressure sensor with tubing and connectors
- Digital balance (readability: 0.01 g)
- Weigh boats
- 500-mL Erlenmeyer flask (2)
- Rubber stopper, one-hole, to fit flask
- Graduated cylinder
- Spatula/scoopula
- Pipets
- Sodium bicarbonate, $NaHCO_3$
- Citric acid ($C_6H_8O_7$) solid, 2.0 g

BACKGROUND

In order to avoid wasting materials, chemists are often tasked with determining precisely how much of each reactant is necessary for a reaction. But what happens to a chemical reaction when the limiting reactant is consumed? This activity explores how you can determine experimentally which of the two reactants, sodium bicarbonate (baking soda) or citric acid, is limiting through several runs of the reaction.

SAFETY

Follow these important safety precautions in addition to your regular classroom procedures.

- Wear safety goggles at all times.
- The gas being generated causes an increase in pressure which may expel the stopper from the bottle. Firmly hold the stopper in place during the experiment but avoid squeezing the body of the sampling bottle/flask.
- Do not point the sampling bottle toward yourself or anyone else.

PROCEDURE

1. **<u>First lab partner begin here</u>:** Using a graduated cylinder, measure 400 mL of water and put it in an Erlenmeyer flask.
2. Use an electronic balance to measure 3.46 g of $NaHCO_3$ and add it to the water in the Erlenmeyer flask. With a stopper on, gently swirl the mixture until it is completely dissolved. You now have 400 mL of a 0.12 M $NaHCO_3$ solution.
3. **<u>Second lab partner begin here</u>**: Open SPARKvue.
4. Open the 08D Determining Limiting Reactants lab file in SPARKvue.
5. Use the Bluetooth icon to connect the Pressure sensor.
6. Make sure that the pressure sensor is correctly assembled as shown here. Check all the attachments to make sure they are snug and secure.

7. **<u>First lab partner</u>:** Pour just under 40 mL of the sodium bicarbonate solution into the graduated cylinder. Use a pipet to make sure you have exactly 40.0 mL. Have the same person read the graduated cylinder each time for precision.

8. Pour the sodium bicarbonate solution you just measured into the new Erlenmeyer flask that you will use for your experiment.

9. **<u>Second lab partner</u>:** Obtain about 2.0 g of citric acid in a weigh boat and take it to your lab station. Use a digital balance to measure about 0.10 g of the citric acid into a separate weight boat. Record the exact mass in Table 1 on your answer sheet.

10. **<u>Both partners together:</u>** Do a "dry run" of steps 11 – 14 below without actually adding chemicals so that you will know exactly what to do and expect.

11. Start collecting data in Sparkvue.

12. <u>It is very important to complete this step as quickly as possible.</u> As soon as one lab partner pours the solid citric acid into the bottle, the other lab partner immediately seals the bottle/flask very tightly with the stopper. Avoid squeezing the sides of the bottle/flask.

13. Hold the stopper <u>very tightly</u> in place and at the same time gently swirl the bottle to help the reactants mix. Continue holding the stopper and swirling at the same speed for the duration of the reaction.

14. Stop collecting data when the reaction is complete and the pressure has leveled off on the graph.

15. Slowly remove the stopper to release the pressure from the bottle.

16. Pour the contents of the bottle/flask into the sink. Thoroughly rinse the bottle/flask with water.

17. Repeat steps 11 - 14 for 0.20 g, 0.30 g, 0.40 g, and 0.50 g of citric acid. Make sure all runs are visible in SPARKvue as you collect data. Label each run on your graph with the mass of citric acid you used.

18. One partner start cleaning up while the other partner starts working on your graphs.

<u>Clean Up</u>

19. Return the pressure sensor with tubing and connectors to the front of the room.

20. Make a beaker of soapy water and wash everything that touched chemicals – weigh boats, flasks, stopper, spatula, graduated cylinder, pipets. Rinse well.

21. Dry and return the Erlenmey flasks and extra stopper to the front of the room.

<u>Analyzing Data & Graphing Your Results</u>

22. On the SPARKvue graph, change the title to your class period and the last names of the lab partners.

23. Scale the graph and then BOTH PARTNERS take a screen shot of the graph and put it in your Google Drive or paste it into a Google Doc in your Google Drive. You will need to use data from this graph to make a second graph and to complete your lab sheets.

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ANALYSIS

1. Use the data from your expiment and from your SPARKvue graph to find mass, initial pressure, final pressure, and pressure change. Record the values in Table 1 below.

Table 1 – Pressure Change

Trial #	Approximate Mass of $C_6H_8O_7$ (g)	Exact Mass of $C_6H_8O_7$ (g)	Initial Pressure (kPa)	Final Pressure (kPa)	Change in Pressure (kPa)
1	0.10				
2	0.20				
3	0.30				
4	0.40				
5	0.50				

2. Plot the data and calculations from your experiment in the graph below. Plot change in pressure (kPa) on the y-axis and exact mass of citric acid (g) on the x-axis. Be sure to label each asis and include a title for your graph.

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3. Each trial in this experiment used the same amount of $NaHCO_3$. Explain why.

4. What happened to the pressure as you added increasing amounts of citric acid? Why did this happen?

5. On the second graph. What was plotted on the x axis and on the y axis? Explain why.

6. Based on your graphs, what is the ideal amount (in grams) of citric acid that you used to produce the greatest amount of products without wasting any material? Explain how you determined this answer.

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7. Which reactant, if any, was a limiting reactant in each trial? Enter your responses in the table below. Support your answers with evidence from the lab.

Evidence for the Limiting Reactant

Trial #	Limiting Reactant	Supporting evidence
1		
2		
3		
4		
5		