

# Stoichiometry Balloon Races

## Limiting and Excess Reactants

### Introduction

Most stoichiometry calculations in the classroom are performed using exact (stoichiometric) molar ratios of reactants and products. In real life, however, many commercial processes for preparing compounds are carried out using a molar excess amount of one reactant (and, thus, a limiting amount of another reactant). This demonstration uses the well-known reaction of sodium bicarbonate and acetic acid to illustrate the concepts of limiting and excess reactants. By comparing the amount of carbon dioxide generated when varying amounts of sodium bicarbonate react with a given amount of acetic acid, students will be able to identify immediately the limiting and excess reactant in each case.

### Concepts

- Stoichiometry
- Limiting reactant
- Molar ratio
- Excess reactant

### Materials

Acetic acid,  $\text{CH}_3\text{COOH}$ , 1 M, 150 mL  
Sodium bicarbonate,  $\text{NaHCO}_3$ , 16.5 g  
Balance, centigram (0.01-g precision)  
Balloons, 6  
Erlenmeyer flasks, 125-mL, 6  
Funnel  
Graduated cylinder, 25- or 50-mL  
Permanent marker  
Powder  
Spatula  
Weighing dishes, 6

### Safety Precautions

Acetic acid is a skin and eye irritant. Avoid contact with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Please consult current Safety Data Sheets for additional safety information.

### Preparation

1. Label six Erlenmeyer flasks 1–6. Using a graduated cylinder, add 25 mL of 1 M acetic acid to each flask.
2. Obtain six weighing dishes, and label them 1–6.

3. Measure the appropriate masses of sodium bicarbonate into each weighing dish, according to Table 1.

Table 1.

Sample	1	2	3	4	5	6
Mass $\text{NaHCO}_3$	0.50 g	1.00 g	1.50 g	2.00 g	2.50 g	3.00 g

4. Obtain six balloons. Stretch the balloons, and blow them up at least once, then let out as much air as possible.
5. Use a powder funnel to add sodium bicarbonate sample 1 to one of the balloons.
6. Flatten out the balloon to remove any extra air, then carefully stretch the neck of the balloon over the mouth of Erlenmeyer flask 1. Do not allow the solid to drop into the flask at this time.
7. Repeat steps 5 and 6 with sodium bicarbonate samples 2–6.

### Procedure

1. Introduce the concepts of limiting and excess reagents by asking students how many automobiles can be assembled if the following parts are available: 140 car bodies, 520 tires and 270 headlights.
2. Which automobile part is present in a quantity that “limits” the total number of automobiles that may be assembled? Is the limiting part the same as the part that is present in the least number? Explain. *Note:* The tires are the limiting parts in this example, even though there are more tires than anything else.
3. Show students the balloon/flask assemblies and ask them to predict what will happen when the sodium bicarbonate is added to the acetic acid in the flask. Write the reaction equation on the board.
4. Line up flasks 1–6 from right to left on the lecture desk. Lift each balloon in turn and shake it to allow the solid to fall into the solution. Make sure the neck of the balloon stays firmly attached to the flask.
5. The reactions will be immediate and vigorous. The white solids will dissolve, the solutions will start to bubble and fizz, and the balloons will become inflated.
6. Allow the reactions to proceed until the bubbling stops. Compare the size of the inflated balloons and whether all the solid has dissolved in each case. (The balloon size should increase fairly uniformly for flasks 1–5, and then stay constant. It may be hard to tell the difference between flasks 4, 5 and 6.)

# Stoichiometry Balloon Races Limiting And Excess Reactants Answers

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