Activity: Farfalle Stoichiometry

FOR THE TEACHER

Summary
In this activity, students will use a hands-on manipulative (pasta) to represent the stoichiometric relationships in a compound and in a balanced equation. They will determine the limiting reactant for a given amount of two reactants and they will identify the excess reactant. In the extension exercise, students will balance the equations that are used in the production of ammonia, a common chemical fertilizer.

Grade Level
High School

NGSS Alignment
This activity will help prepare your students to meet the performance expectations in the following standards:
- **HS-PS1-7**: Use mathematical representation to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- **Scientific and Engineering Practices**:
  - Using Mathematics and Computational Thinking
  - Developing and Using Models

Objectives
By the end of this activity, students should be able to
- Represent a simple synthesis reaction with the use of manipulatives.
- Represent the stoichiometric ratio of elements in a compound using manipulatives.
- Determine the limiting reactant when given the initial reactant amounts in moles.
- Determine the excess reactant when given the initial reactant amounts in moles.
- Balance a simple chemical equation.

Chemistry Topics
This activity supports students’ understanding of
- Stoichiometry
- Limiting Reactants
- Excess Reactants
- Balancing Equations

Time
**Teacher Preparation**: 10 minutes
**Lesson**: 30 minutes

Materials
- 1 pound box (454 grams) of Farfalle (bowtie pasta) or other shapes
- 1 pound box (454 grams) of miniature shells pasta (avoid using ziti—it rolls off the table!)

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.
- Food in the lab should be considered a chemical not for consumption.
Even though this is pasta, we are placing it onto chemistry laboratory table. This makes it unfit for eating.

Teacher Notes

- Materials listed are suitable for a class of approximately 24 students and can be reused for subsequent classes.
- Teachers should place a handful of Farfalle pasta and a handful of mini shells in front of each student work space. Make sure the number of pasta pieces are not a prime number
  - Write prime numbers on the board at the front of the class (1, 3, 5, 7, 11, 13, 17, 19 or 23)
  - Ask students to count each type of pasta and make sure they do NOT have a prime number of either type of pasta.
  - I suggest double checking their numbers also.
- Do not hand out ALL of the pasta, reserve some for corrections.
- If they DO HAVE a prime number, give them one more piece of that type of pasta (making it an even number) and they will have an easier time completing the activity.
- For beginner level students, it helps to have a simple ratio (2:1 or 3:1 or 4:1) of the pasta (farfalle : miniature shells).
- For more advanced learners change the pasta ratios to 2:3 or 5:3 or 3:7.
- Students can mix the pasta at their own station (don’t leave the different types of pastas grouped) then switch stations with another student to try a different ratio.
- When students have completed three stations they should be ratio masters!
- Students should collect the pasta to reuse for another class.
- An Answer Key document has been provided for teacher reference.

For the Student

Lesson

Farfalle Stoichiometry

Background
Chemistry is often referred to as “the invisible science” because in chemistry we often talk about atoms and molecules that cannot be seen. In this activity, we will use two different types of pasta (which we CAN see) to represent two different types of atoms (which we cannot see). The limiting reactant in a chemical reaction is the reactant that limits, or stops the reaction because it runs out first.

Prelab Questions
1. What is the mathematical relationship between the total mass of all reactants and the total mass of all products in a balanced chemical reaction?

2. How do the subscripts in a chemical formula relate to the ratio of each atom within a compound?

3. When we have two different reactants in a synthesis reaction, how does one define the limiting reactant?

4. When we have two different reactants in a synthesis reaction, how does one define the excess reactant?

Materials
- Two different types of uncooked pasta
Safety
- Food in the lab should be considered a chemical not for consumption.
- DO NOT EAT the pasta used in this activity.
- Wash your hands when you have completed the activity.

Procedure
1. Record the number of each type of pasta that you have. (Each person has a different number).
   If one of your quantities is a prime number (1, 3, 5, 7, 11, 13, 17, 19 or 23) raise your hand so the teacher can correct this.
   
   Farfalle (bow tie) = \hspace{1cm} Miniature Shell =

2. Group the pasta with a 1:1 ratio (1 farfalle to 1 shell)
   
   How many groups did you make?

3. Write a “pasta equation” for making these groups:
   
   ___Farfalle + ___Shell \rightarrow ___Farfalle_1 Shell_1 + ____ extra _________ pasta

*Notice there are subscripts of 1 to emphasize the 1:1 ratio of the two types of pasta.

Example:

   _6_ Farfalle + _8_ Shell \rightarrow _6_ Farfalle_1 Shell_1 + _2_ extra shell pasta

This shows that we start with 6 Farfalle and we end with a compound using all 6 Farfalle. There are 8 shells as a reactant and 6 shells in the compound plus 2 extra shells.

4. Which pasta ran out first? (farfalle or shell)

5. Which pasta was “in excess”? (farfalle or shell)

6. Which pasta was the limiting reactant in this equation? (farfalle or shell)

7. Now create a ratio where all pasta are used. Place the pasta in groups so that each group has the same ratio
   
   ___Farfalle : ___Shell

8. How many different groups did you make? The number of groups corresponds to the number of molecules or the number of moles for a compound in the balanced equation.
9. Write a pasta synthesis reaction substituting the ratio from #7 as the subscripts in your final pasta compound:
   - Fill in the total number of pasta you counted at the start as the coefficients of the reactants.
   - Write the number of groups you made as the coefficient of your new compound (FarfalleShell). Write the subscripts of FarfalleShell as the numbers of each pasta in one group.

Example:

\[
12 \text{Farfalle} + 8 \text{Penne} \rightarrow 4 \text{Farfalle}_3 \text{Penne}_2
\]

\[
\text{___Farfalle} + \text{___Penne} \rightarrow \text{___Farfalle} \text{___Penne}
\]

*Remember*: The coefficients of a balanced chemical equation represent the number of MOLES of each compound NOT the mass of the compound. You have been counting HOW MANY pasta pieces not the MASS of the pasta!

10. Using the given pasta, make a model of the ammonia synthesis reaction. Ammonia is used as a commercial fertilizer, for food production. Below is the UNBALANCED reaction. Represent nitrogen atoms with Farfalle pasta and represent hydrogen atoms with mini shells.

\[
\text{__N}_2 + \text{__H}_2 \rightarrow \text{___NH}_3
\]

First balance the equation. Then group the pasta to represent the balanced equation.

11. Sketch your pasta representation of the equation below:

**Calculations**

Use the balanced ammonia equation to complete the following questions. Show all work.

\[
\text{__N}_2 + \text{__H}_2 \rightarrow \text{___NH}_3
\]

1. How much ammonia (moles) can be made from 4 moles of hydrogen?
2. How much ammonia (moles) can be made from 2 moles of nitrogen?
3. If 4 moles of hydrogen AND 2 moles of nitrogen are combined, which one is the limiting reactant?
4. How many moles of the excess reactant will remain when the reaction is finished?
5. What happens to the reaction when the limiting reactant is completely reacted?
6. If 500g of nitrogen and 1000g hydrogen are combined, which is the limiting reactant and how much of the excess reactant is left over?