Activity: A Stoichiometry Puzzle

FOR THE TEACHER

Summary
In this activity, students will develop a better understanding of how to set up a stoichiometry problem using dimensional analysis (factor label method). Students will be able to use their prior knowledge of mole conversions and chemical reactions.

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

- Use dimensional analysis (factor label method) to solve a stoichiometry problem.
- Set up a conversion correctly.
- Determine the appropriate conversion to use.
- Quantitatively determine the amount of reactant or product needed in a chemical reaction.
- Understand that mass is conserved and atoms are simply rearranging in a chemical reaction.

Chemistry Topics
This activity supports students’ understanding of

- Chemical reactions
- Moles
- Nomenclature
- Dimensional analysis
- Conservation of mass

Time
**Teacher Preparation**: 1-2 hours* (only if you choose to make your own worksheet and conversion sheet, otherwise just time to make copies)
**Lesson**: 30-90 minutes

Materials

- Photocopied paper of conversion outline for factor label/dimensional analysis (see attachment)
- Scissors
- Periodic table
- Calculator
- Chalk or individual whiteboards

Safety

- No specific safety precautions need to be observed for this activity.

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Thanks to:
Dow Chemistry Teacher Summit
Teacher Notes

- Prior to teaching this topic the students should have an understanding of:
  - predicting products in a chemical reaction
  - balancing a chemical equation
  - mole conversions (gram to mole, mole to molecule, molarity and volume, liters to mole for a gas at STP conditions)
  - nomenclature for ionic and covalent compounds

- This activity can be used as a review, introduction to stoichiometry, or as a differentiation for struggling learners.

- The idea behind the activity is that it is a game/puzzle to help students see the matching aspect of factor label/dimensional analysis.

- Some of the pieces for the puzzle (which are on the attachments to the student activity) can be used more than once.

- The students should work in groups of 3-4 and you should be sure to have at least one strong student in each group, if possible. It is best for you to determine the grouping of the students.

- The activity is done as a graduation moving from giving students the complete conversion, to the top or bottom of the conversion, to having them do the entire conversion themselves.

- This activity is for students who are struggling with stoichiometry if you are using it as a review the activity might only take 15-20 minutes because strong students would get it quickly.

- I would make sure you do the activity in the classroom so that you can help any students who are not setting up the conversions correctly.

- Students will spend time cutting out the conversions, which you will have printed on sheets to give them. I also put multiplication, equal signs and lines for the factor label/dimensional analysis set up.

- Students will be building the conversions on the desks. I find it best to work on lab benches since they are nice and long. Then having the work checked by you before they write the completed work onto their worksheet.

- Another option is to have students complete the work in two other ways:
  - If you have black tables where students work, they can write on the table top with chalk. If not whiteboards will work, but you will need a class set of expo markers.
  - You can have students write the final equation on the paper. I find students really enjoy writing on the desks with chalk and it adds another level to the activity making it not just a worksheet.

- While you are doing the activity, it might be helpful to stop after the students have solved questions #1 and have a discussion about using factor label/dimensional analysis. You could discuss limiting reactants. This would be a great time to discuss how stoichiometry is used in the real world. There are so many connections you can make, pharmaceutical industry, any manufacturing industry, textiles, etc. You can talk about the importance of knowing how much material you need to make a specific amount of product to help students understand the importance for being able to learn stoichiometry.

- You can use any worksheet make it as simple or complex as you want this is a guide to give you an idea of what you could do.
A Stoichiometry Puzzle

Background
Stoichiometry is a fun word to say but what does it mean? Stoichiometry is about relating the reactants and products in a reaction quantitatively (using math). This involves using conversions to get from one reactant or product to another constituent in an equation. A simple way to set up conversions is using a technique called the factor label method or dimensional analysis.

Prior Knowledge Questions
1. Calculate the molar mass of aluminum hydroxide, Al(OH)₃.
2. What is the unit for molar mass?
3. What is Avogadro’s number of molecules in 1 mole of Al(OH)₃?

Materials
- Scissors
- Chalk or Expo markers and whiteboard

Directions
1. Follow the directions below for solving the 3 stoichiometry problems provided.
2. Gather your materials: scissors and chalk (or expo markers and whiteboards).
3. Follow the directions provided on the “Cut Out“ handouts to properly cut-out each of the conversions and math symbols for the appropriate questions.
4. Refer to question 1 below. You are looking for all the pieces to solve question 1a, how many moles of Al₂O₃ are produced.
5. Using your cut-outs, you will determine which conversions to use and then set them up correctly together using the math symbols.
6. Once you have it set up, have your teacher check it and then solve for the answer and write the full worked out problem in the space provided.
7. Attempt to complete the rest of the problems in question 1 using the appropriate cut-outs as your conversions.
8. Don’t forget to have your teacher check to make sure your set up is correct and solve each problem for the answer while also recording your work.
9. When you are comfortable move onto question 2. For this question, you don’t have the entire conversion available as a cut-out, only pieces of it.
10. Cut out the pieces for the conversions and math symbols for question 2.
11. Review question 2 and determine what pieces you need and where they go in order to calculate the mass of barium nitrate produced.
12. Once you have the conversions set up have your teacher check it before you transfer the correct work onto your paper.
13. Complete question 3, using your calculations from 1 and 2 as a guide if you get stuck.
Stoichiometry Questions

1. Use the following equation for the oxidation of aluminum in the following problems.

\[ 4 \text{Al} + 3 \text{O}_2 \rightarrow 2 \text{Al}_2\text{O}_3 \]

a. How many moles of \( \text{Al}_2\text{O}_3 \) is produced from 0.32 mol Al and 0.26 mol \( \text{O}_2 \)?

b. How many moles of \( \text{Al}_2\text{O}_3 \) are formed from the reaction of 6.38 grams of \( \text{O}_2 \) and 9.15 grams of Al?

c. How many grams of \( \text{Al}_2\text{O}_3 \) are formed from the reaction of 1.88 grams of Al and 1.88 grams of \( \text{O}_2 \)?

d. How many grams of \( \text{Al}_2\text{O}_3 \) are formed from the reaction of \( 8.32 \times 10^{20} \) molecules of \( \text{O}_2 \) and \( 4.26 \times 10^{21} \) molecules of Al?

e. In problem a, which reactant was limiting?
   In problem b, which reactant was limiting?
   In problem c, which reactant was limiting?
   In problem d, which reactant was limiting?

f. What conclusion can you make about the limiting reactant?

2. In the following reaction what mass of \( \text{Ba(NO}_3\text{)}_2 \) can be formed by combining 55.0 g \( \text{BaCO}_3 \) and 55.0 g \( \text{HNO}_3 \)?

\[ \text{BaCO}_3 + 2 \text{HNO}_3 \rightarrow \text{Ba(NO}_3\text{)}_2 + \text{CO}_2 + \text{H}_2\text{O} \]

3. Nickel displaces silver from silver nitrate in solution according to the following equation:

\[ 2 \text{AgNO}_3 + \text{Ni} \rightarrow 2 \text{Ag} + \text{Ni(NO}_3\text{)}_2 \]

If you have 112 g of Ni and 112 g of \( \text{AgNO}_3 \), how many atoms of silver would be produced?