Stoichiometry Explained Through Particle Diagrams

Submitted by: Allison Hardy, Chemistry
Hillwood High School, Memphis, TN

Target Grade: 10th-12th Grade Chemistry

Time Required: 60 minutes

Standards

Next Generation Science Standards (NGSS):

- HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Lesson Objectives

Students will be able to:

- Describe the purpose of stoichiometry and conversions.
- Explain the connection between particle diagrams and stoichiometry.
- Describe the relationship between mole ratio and the coefficients present in a chemical reaction.
- Represent how coefficients are connected to the amount of reactants available through analysis of a particle diagram.
- Analyze two step stoichiometry problems for potential math mistakes and recognize common errors.

Central Focus

This virtual lesson plan will allow students to further their understanding of balancing and manipulating chemical equations. They will use stoichiometry to calculate mole ratios, analyze chemical reactions, and identify relationships between reactants and products. Students will apply their knowledge of chemical reactions to represent the situation using particle diagrams.

Key terms: Chemistry, problem solving, groups, at home, digital, online, molar mass, limiting reagent, conversions, Law of Conservation of Mass

Background Information

This lesson plan will act as a review for balancing equations. Prior to the lesson, students should be aware of the following terminology:

- Stoichiometry: The study of amounts of reactants used and products formed in a chemical reaction. It is used to balance chemical equations, convert units, and determine the amount of product yielded by a chemical reaction.
- A ratio is the quantitative relation between two amounts showing the number of times one value contains or is contained within the other.
- A mole ratio is a ratio between the numbers of moles of any two substances in a balanced chemical equation. Mole ratios are written as ratios or fractions.
- The molar mass of a compound is the mass of a sample of that compound divided by the amount of substance in that sample, measured in moles. It can be found on the periodic table.
- Reactants are the ingredients used to start the reaction. They are located on the left hand side of the arrow.
- Products are the result of the reaction, and they are located on the right side of the arrow. They are what is left over after a reaction has occurred.
- When the equation is balanced the coefficients tell you how many moles you need and how many moles you end up with.
- Law of the Conservation of Mass: The total mass of the reactants is equal to the total mass of the products. Matter is not created or destroyed.
- Particle Diagrams, Direct vs. Indirect Relationship, Claim, Evidence, Reasoning, Quantitative Data, Qualitative Data, Computational Model

Figure 1 https://byjus.com/chemistry/chemical-equation/

Students will need to understand how to read balanced equations. They will also need to understand that energy/matter is not created or destroyed during chemical reactions, so the quantities of each element must remain the same on each side of the equation. Students should also have previous knowledge of how to convert from more familiar units (ex. grams) to moles.

For this lesson, the teacher should have content knowledge of the following:

- Ratios
- Mole ratios
- Symbolic particulate representations for chemical equations: A representation in which each element or particle is represented by a unique symbol.
- Limiting reagent: A reactant that is totally consumed when the chemical reaction is completed.

Throughout the lesson, the teacher should emphasize that stoichiometry is important because it allows us to calculate the quantity of each reactant we will need in order to get a desired amount of product. The teacher should also emphasize how mass is conserved when working with mole ratios and limiting reagents. The Law of Conservation of Mass will be demonstrated physically with a baking soda and vinegar reaction. Then students will use the law when mathematically manipulating chemical equations.

This lesson should come after lessons on unit conversions and balancing chemical equations. It should precede lessons about limiting reagents. This lesson will introduce the concept of a limiting reagent through manipulations of chemical equations and identifying what is left over after the reaction.

Materials

Technology:

- Individual laptop computers (1 for each student in the class)
- Access to reliable Wi-Fi network
- Chargers for laptops to prevent battery shortage issues
- Google Slides (for students to edit): https://docs.google.com/presentation/d/1nzilEyCd4_3MlSkSKNI0dNhr3TwxerC42J9rAicNy24/edit?usp=copy
- Phone timers to provide structure to instruction
- HW Worksheet: Two Step Problems

Teacher Demonstration Resources:

- 4 Clear bottles
- 4 Gloves
- Vinegar
- Baking Soda
- Scale

Instruction

Introduction (6 min)

Slide 1

- In the chat box of the online classroom have students answer the following question:
    - Imagine that you work at a bakery and you have to make 45 moles of cookies. Given the chemical equation below, how many moles of chocolate chips do you need?
- After students have answered, lead a class discussion and reflect on prior knowledge (balancing equations, conservation of mass, coefficients in a chemical reaction).

Slide 2-4

- Review the day's agenda and objectives.

Review (8 min)

Slide 5-9

- Review and allow students to ask questions about converting from grams to moles (Slide 7).
- Introduce the idea of a mole ratio and then allow students to practice calculating mole ratios (Slides 7-9).

Demonstration (7 min)

Slide 10-11

- Remind students of good ways to make observations:
    - Color change, smells or odors, bubbles, formation of solid, etc.
- Students will use the provided sentence stems.
    - I observed____.
    - This reminds me of____ because____.
    - I wonder why____.
- Demonstrate baking soda with vinegar reactions for students. Start by weighing the bottles, vinegar, baking soda, and gloves. Then pour vinegar into four clear bottles. Next, add small portions of baking soda to each glove. Seal the glove over the lid of the bottle, and slowly dispense the baking soda from the glove into the vinegar. The chemical reaction will cause the glove to expand. Weigh the materials after this reaction to show that the overall mass has not changed. (Example video: https://www.youtube.com/watch?v=kfY-FgYxT8A).
- Review the students' comments in the chat box.
- Ask students probing questions to help draw connections from the experiment to the Law of Conservation of Mass.
- Example questions:

- How much do you think the product will weigh? Explain your reasoning.
- What are ways we can represent or explain this reaction?
- Was matter created or destroyed in this experiment? Explain your reasoning.

Class Check-in (2 min)

Slide 12

- Allow students to select which image they connect to based on their feelings about the content.
- Reflect on students' responses.

Diagram Investigation (15 min)

Slides 13-19

- Introduce and demonstrate symbolic particulate representations using the chemical equation $2H_2 + O_2 \rightarrow 2H_2O$. Discuss the idea of limiting reagents.
- Introduce the google slides to the students and how to manipulate them.
- Go over expectations for manipulating the slides and group work.
- Group work expectations:
  - Communicate with members about your technology.
  - Be present on the slides.
  - Ask questions in Teams Chat or on slides!
- Ask students probing questions like the following:
  - Do we have any leftover starting material?
  - Is there a limiting reagent? If so, what is it and how do you know?
  - How does this show matter cannot be created or destroyed?
  - How are molar ratios used in this manipulation?
- After placing the students in groups, allow students to begin manipulating their assigned slide.
- Students will:
  - Determine if they agree or disagree with the model for the products presented to them.
  - Explain why they agree or disagree.
  - Generate a revised model for the products using the particles on the slide.
  - Have the opportunity to reflect on other student's PowerPoint slides.
- After students have finished working, provide verbal and written feedback on the slides to groups and individual students.
- Lead a class discussion reflecting on students' work and the correct diagrams.

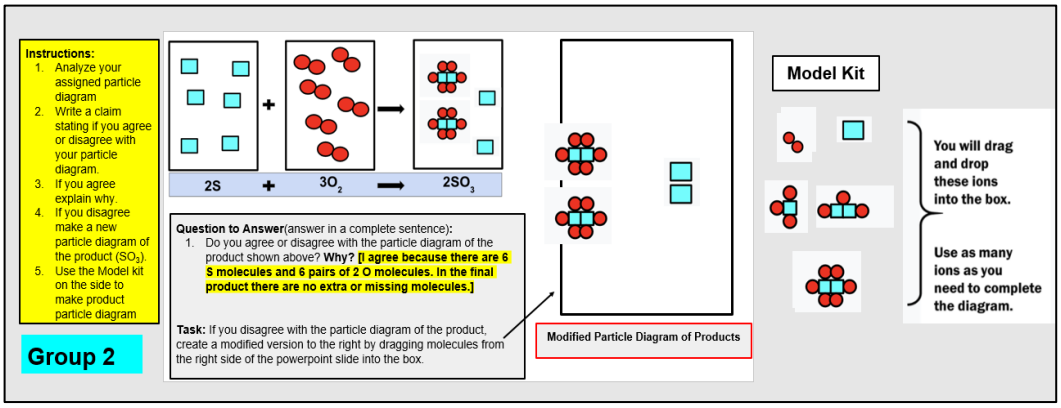


Figure 2: Particle diagrams for students to manipulate

Common Math Mistakes (10 min)

Slides 20-21

- Show students common math mistakes and have students locate the potential error through chat participation.

Closing (5 min)

- Provide students with the homework sheet.
- Complete the first problem with the students.
- Reflect on the schedule for the rest of the week.

Differentiation

- Group students in intentional ways. Use heterogeneous slide assignment of students who work well together and help to create an on-task academic environment for all students in the classroom. Slide arrangements include an attempt to group students with varying abilities and personalities.
- Students can often struggle with the math necessary for this lesson. The teacher may want to do a short review session prior to this lesson for the whole class or for students who need it so that they are prepared to do the activities.

Students with disabilities:

- For students with IEPS or 504s or special needs, provide sentence stems for the argumentation sessions.
- Group students together with peers who are familiar with supporting them and who they have a good rapport with.
- For struggling readers and writers, include a variety of points of access including:

- guided notes for lecture
- relevant images on the PowerPoint
- demonstrations of vocabulary
- whole class discussion of sentence stems/routines/norms
- use of visuals to explain stoichiometry

English Language Learners:

- Make a class packet of direct translation using Google translate. Encourage them to write their responses in English and only use the direct translation packet if necessary.
- Students will be allowed to use their phones and the computers to use google translate so that they can participate in discussions.
- Depending on students' level, they will be grouped with another student who can provide translations.
- Students will be provided with opportunities in each lesson to interact with the four language demands (writing, reading, speaking, and listening).
- Visuals are frequently provided and students are grouped to provide them with opportunities for success.
- Provided sentence stems for the argumentation sessions.
- The teacher can create a premade vocabulary list of important terms with definitions in English and the students' L1.

Advanced Learners

- Have students research more complicated chemical reactions and calculate mole ratios using these equations.
- Let these students facilitate their groups' discussion.
- Some advancing questions to ask: Why do you think mole ratios are important or useful? How do you think scientists use what we are doing?

Assessment

Formative assessment:

- The teacher can use chat box responses and class discussion to check progress throughout the lesson.
- The group work on the slides can also be used during the lesson to evaluate the students' understanding of the material.

Summative assessment:

- The students' final homework will allow the teacher to gauge student understanding of the lesson.

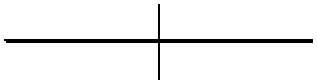
HW Worksheet: Two Step Stoichiometry Practice Name: _____

Directions: Answer the following questions, circling your final answer for ease of grading. Show all of your work and be sure to include units!

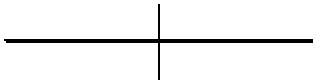
Answer the following questions given the following equation:

$$N_2 + \mathbf{3}H_2 \rightarrow \mathbf{2}NH_3$$

1. How many **moles** of ammonia, NH_3, will form if one uses **5.5 moles** of H_2?

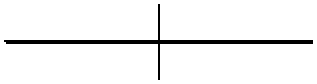


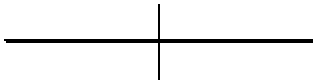
2. How many **moles** of ammonia, NH_3, will form if one uses **5.5 moles** of N_2?



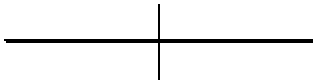
3. Based on your answers to 1 and 2, what is the limiting reagent in this reaction? How do you know?

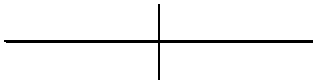
4. How many **grams** of hydrogen, H_2, are necessary to react with **13.5 moles** of N_2?





5. How many **grams** of nitrogen, N_2, does one need if one uses **6.5 moles** of H_2?





Answer the following questions given the following equation:

$$\mathbf{4}P + \mathbf{3}O_2 \rightarrow \mathbf{2}P_2O_3$$

6. How many moles of diphosphorous trioxide, P_2O_3, will form if one uses 2.5 moles of O_2?

7. How many moles of diphosphorous trioxide, P_2O_3, will form if one uses 2.5 moles of P?

8. Based on your answers to 7 and 8, what is the limiting reagent in this reaction? How do you know?

9. How many grams of diphosphorous trioxide, P_2O_3, will form if one uses 4.5 moles of P?

10. How many grams of diphosphorous trioxide, P_2O_3, will form if one uses 3.5 moles of oxygen?