CHEMISTRY

Standard(s):

(C.8) The student can quantify the changes that occur during chemical reactions. *The student is expected to:*

(A) use the concept of a mole.

(G) perform stoichiometric calculations, including determination of mass relationships between reactants and products and percent yield.

(H) Describe the concept of limiting reactant in a balanced chemical equation.

CONCEPTS (NOUNS)

Stoichiometry

Mole ratio

Percent yield

Limiting reactant

Excess reactant

SKILLS (VERBS)

Demonstrate

Investigate

Plan and implement

Collect and express

Calculate

Analyze, evaluate,

LEARNING PROGRESSION

1. The students understand the concept of reactants and products and how to balance a chemical reaction from previous lessons units.
2. Perform laboratory investigations to classify the five main chemical reactions.
3. Perform stoichiometry calculations.
4. Define stoichiometry, mole ratios, limiting reactant percent yield, actual yield, and theoretical yields.
5. To predict the amount of products, the students understand the role of the reactants and how a reactant limits the amount of products based on stoichiometric calculations for determining limiting reactants.
6. Design and/or plan how to carry out a chemical reaction and determine the amount of products in grams, based on the amount of given reactants.
7. Collect data, analyze the data to perform stoichiometric calculations, including determination of mass relationships between reactants and products and percent yield.
8. Justify sources of error based on the %yield calculations from the actual yield and theoretical yield obtained via stoichiometric calculations. Students analyze and evaluate the accuracy of predicting the products based on the mole of reactants to products ratios.

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LEARNING INTENTIONS	SUCCESS CRITERIA	RELEVANCE TALKING POINTS
1. I am learning to use the mole ratio in stoichiometric calculations.	1a. I can balance a chemical equation and determine mole ratios.	1a. Mole ratios are important for determining the amount of reactants and products used in a chemical reaction.
	1b. I can use molar mass and the mole ratio to calculate the number of moles or number of grams of a substance in a reaction.	1b. Relating the amount of substances to one another in a chemical reaction requires expressing the mole ratios and molar masses of each substance in moles. This is similar to preparing and cooking meals.
	1c. I can define and explain mole ratios.	1c. Mole ratios are determined from the coefficients present for each substance when the chemical reaction is represented in a balanced chemical equation.
2. I am learning about the importance of predicting the products produced in a chemical reaction.	2a. I can identify the reactant(s) and product(s) from a chemical reaction.	2a. Chemists understand the chemical properties of the reactants to predict the products produced in a chemical reaction.
	2b. I can predict what products will form from a given chemical reaction.	2b. I am able to provide examples of instances when it is important to predict the amount of product based on the amount of reactants and which reactant limits the chemical reaction.
3. I am learning about limiting reactants.	3a. I can illustrate the concepts of limiting reactants and excess reactants. 3b. I can perform stoichiometry calculations to determine the limiting reactant.	3a. It helps to determine the amount of products produced in a chemical reaction.

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4. I am learning how to calculate the percent yield	4a. I can define theoretical yield and actual yield.	4a. A balanced chemical equation is necessary to predict the amount of product(s) and differentiate between the actual yield and the theoretical yield.
	4b. I can explain how to calculate percent yield.	4b. The percent yield allows chemists to determine possible sources of error to maximize the amount of product produced.

ASSESSMENT OPPORTUNITIES

Provide a stoichiometry problem for students to balance the chemical equation for any chemical reaction. The students analyze the given quantities for each reactant and begin to complete the provided chart as "Given", "Unknown", "Conversion Factors" and "Solve". The students solve the problem using factor labeling, also known as dimensional analysis.

The teacher will monitor how students complete the chart and allow students to work within the group to develop strategies on how to solve the stoichiometric problem. Pay attention to how students answer "What is the problem asking you to solve? What is the problem? What are the known quantities the problem provided you with? How many conversion factors do you need to solve the problem? How do we know when to add, multiply, and/or divide?"

Allow students to use the board or other opportunities when working on the pre-lab and lab analysis sections. Use the following guiding questions to assess if the students are mastering the success criteria:

- What is the concept of mole ratio as used in reaction stoichiometry problems?
- What is molar mass? What is its role in reaction stoichiometry?
- Distinguish between ideal and real stoichiometric calculations.
- How do you calculate the percent yield in reaction stoichiometry?
- How does the value of the theoretical yield generally compare with the value of the actual yield?

CREATING MEANINGFUL LEARNING EXPERIENCES

Focused Instruction (modeling):

- Last semester, we learned about the importance of using moles in chemical reactions and how it relates to molar mass given the periodic table.
- We also learned the meaning of Avogadro's number when counting particles, molecules, or ions in one mole of substance.

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- Today, we are learning how to use a balanced chemical equation to determine which of the two reactants limits the amount of products obtained during a single replacement reaction and how stoichiometry is the study of measuring quantities in the natural world.
- We are going to use the textbook to define vocabulary terms and learn how to apply the concepts during an exploration section on how to solve the three basic types of stoichiometry problems: mole-to-mole conversions, gram-to-mole/mole-to-gram conversions, and gram-to-gram conversions.
- You will complete each problem independently first, and then work with a partner using the Think-Pair-Share strategy to verify answers and brainstorm on how to develop a stoichiometry roadmap for solving each type of problem.
- I am going to monitor your work and consider the question stems below while guiding you to complete the work. Some problems will allow you to predict the products.

Question Stems:

- *What are the reactants of this reaction? What are the products?*
- *What type of chemical reaction is going to occur/did occur? How would we know?*
- *Do we know the amount of reactant we are using? How would we measure it? How could we determine what products form?*
- *What evidence did we see that a reaction occurred? (flame, heat of bottle, bubbles, color change, presence of carbon dioxide)*

- Students should be able to create a diagram for each type of stoichiometry problem.
- Each group will place their diagrams or roadmaps on chart paper around the classroom to use as a reference for other problems.
- On a different day, with guidance, you will plan/design how to carry out a single replacement reaction and determine the mole ratio to calculate the theoretical yield.

GUIDED PRACTICE

1. This lesson takes three instructional days of 80 minutes each. On the first day, students learn the scientific concepts, practice on how to solve problems as the teacher guides them and then they will solve a different problem independently. After the guided and independent practice, students prepare for the laboratory by reading beforehand the laboratory procedure and completing the pre-lab. On the second day, students design and plan how to carry out one of the two single replacement reactions given reagents and lab equipment shown to them at a station.
2. Students will define in their science journal the following vocabulary words: moles, molar mass, mole ratio, limiting reactant, excess reactant, actual yield, theoretical yield, and percent yield.
3. Model a guided practice example on how to use a balanced chemical equation to determine the limiting reactant and calculate the theoretical yield using stoichiometric calculations.

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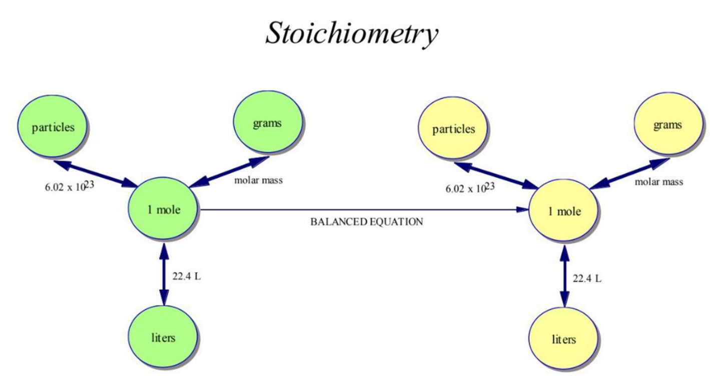
4. Students practice new problems using chart paper. Students read out loud the problem and underline/highlight the following parts: Given, Unknown within the world problem. Then students work with a partner using a "Think-Pair-Share" strategy on what are the conversion factors needed to solve the problems and how to use the underlined/highlighted information for using dimensional analysis.
5. After solving the independent practice problem, students stand in a circle and when prompted, they will show at the same time the chart paper with the process on how they solve the problem. Each group will present the strategies used to solve the problem and report the following: Limiting Reactant, Theoretical Yield, Actual Yield, and Percent Yield.
6. Students will complete pre-lab questions to assess prior knowledge and review scientific concepts as they learn how to determine the limiting reactant. Some of the pre-lab problems would require students to predict the products by naming the product and writing its chemical formula. This reinforces previously learned skills about predicting the products when classifying chemical reactions into the five main types.
7. As to ensure mastery of the concepts, the students will carry out a single replacement reaction. Students will solve a stoichiometry problem on how to determine the limiting reactant and how to calculate percent yield based on reactants and products. Based on empirical data, students will explore how to make claims and justify the prediction of the products based on empirical data.

COLLABORATIVE LEARNING

Students will complete each problem independently first, and then work with a partner using the Think-Pair-Share strategy to verify answers and brainstorm on how to develop a stoichiometry roadmap for solving each type of problem.

INDEPENDENT PRACTICE

Students will be given a set of stoichiometric problems to solve using the strategies taught throughout the lesson and what they learned during the scientific inquiry. Each problem will prompt the students to underline the "Given, the Unknown, and the Conversions Factors" to utilize when solving the problems using dimensional analysis. The students will make use of the roadmaps developed during the guided practice. A similar roadmap is shown below



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ASSESS MASTERY OF STANDARD

The teacher will assess the mastery of standards by using the following components:

1. *Question Stems:*
    - *How would the roadmap help show what to do if we are given moles? Grams?*
    - *Can we use this diagram for different chemical reactions or does it only work for this combustion reaction?*
    - *Which type of problem was the longest to solve? Was it really "harder" or just longer?*

2. **From the laboratory, use the data chart, the calculations, and conclusions provided by the students. For example:**

    DATA Chart:

Mass 250 mL beaker	
Mass 250 mL + copper (II) chloride	
Mass nails before reaction	
Mass nails after reaction	
Mass 250 mL beaker + dry copper	

Calculations:

a. Determine the mass of copper produced and the mass of iron used during the reaction.
b. Calculate the moles of copper and moles of iron involved in the reaction.
c. Determine the ratio moles of copper/moles of iron
d. Express the ratio as an integer. For example, a ratio of 1.33 can be expressed as $\frac{4}{3}$; 0.67 can be expressed as $\frac{2}{3}$, etc.

Conclusion:

a. Why did the reaction stop? Which reactant was used up? How do you know?
b. Describe what was happening to the atoms of iron and copper during the reaction. What is this type of reaction called?
c. What would happen to the ratio of copper to iron if you had placed more nails in the beaker? If you let the reaction go for less time?
d. What is the accepted ratio of copper atoms to iron atoms in this reaction? Write the balanced chemical equation for this reaction.
e. Account for differences between your experimental value and the accepted value? Calculate the %Yield for this reaction.

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3. Have students write a One Minute Paper-see instructions below-answering the following prompt: Why is it important to be able to predict the amount of product that will form in a chemical reaction? In what sorts of industries might this information be critical?

   One Minute Paper Instructions:

   1. Teacher asks students to summarize the ideas, concepts, skills, and processes they learned by writing for approximately 1–3 minutes.
   2. Students may write a paragraph, a bulleted list, or create a graphic organizer.
   3. Students share their one-minute papers through Think and Throw (refer to movement/discourse playlist).
   4. Students turn in their One Minute Paper as an exit ticket.
   5. Students huddle into small groups, share papers, and read out 2–3 of the best.
   6. Teacher evaluates students' responses and adjusts instruction as appropriate.

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