**Empowering Science Teaching and Learning Carol Standefer**

**Assignment #12 - Lesson #2**

**Limiting Reactants**

**Unit Title: Stoichiometry**

**NGSS Performance Expectations:**

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

|  |  |  |
| --- | --- | --- |
| **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| Using Mathematics and Computational Thinking: *Use mathematical representations of phenomena to support claims.*  Developing and Using Models | Chemical Reactions: *The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions*. | Energy and Matter: *The total amount of energy and matter in closed systems is conserved.* |

**Time:** Two 70-minutes class periods

**Objectives:**

* Students will be able to determine the limiting reactant in a chemical reaction using mathematical calculations.
* Students, in groups, will create and model a balanced equation, including a limited reactant, and will represent it in three-dimensional models.

**Introduction: *How many cookies can be made?***

* Students will be presented with a recipe for chocolate chip cookies and a list of available ingredients. They will then work in their table groups to determine to total number of cookies that can be made. (recipe and list attached)
* Students will share their results and give an explanation of how they arrived at their answer. (Explanations will vary, but students should conclude that one particular ingredient limits the total number of cookies that can be made.)

**Lesson:**

1. Access prior knowledge
   1. Balanced equations (law of Conservation of Mass)
   2. Mole ratios from balanced equations (prior lesson)
   3. Mole to mass and mass to mole conversions
2. Definitions
   1. Limiting Reactant: the reactant that limits the amount of the product that can form in a chemical reaction.
   2. Excess Reactant: the reactant in excess (some is left over).
3. Real world example: A truck carrying hydrochloric acid has an accident and 6.3 moles of the acid spills onto the roadway. A clean up crew arrives with 2.8 moles of Ca(OH)2 to neutralize the acid. Is this going to be enough?

Balanced equation: Ca(OH)2 + 2 HCl 🡪 CaCl2 + 2 H2O

* Students work in pairs to try and solve problem mathematically. Volunteers are asked to solve on the white board.
* Solution: 6.3 moles HCl x 1 mole CaCl2/2 moles HCl = 3.2 moles CaCl2

2.8 moles Ca(OH)2 = 1 mole CaCl2/1 mole Ca(OH)2 = 2.8 moles CaCl2

The Ca(OH)2 will be used up before the acid, therefore it is limiting. Not all of the acid will be neutralized.

1. Stoichiometry Inquiry Activity (see attached)
2. Practice problems

***How Many Cookies can be Made?***

**Chocolate Chip Cookies (makes 24 cookies)**

½ cup sugar ½ tsp salt

½ cup brown sugar ½ tsp baking soda

1 1/3 stick butter 1 ½ cup flour

1 egg 1 1/3 cup chocolate chips

1 tsp vanilla

**Available Ingredients:**

1 dozen eggs

24 tsp of vanilla

1 lb. (82 tsp) of salt

1 lb. (84 tsp) of baking soda

3 cups of chocolate chips

5 lb (11 cups) of sugar

2 lb (4 cups) of brown sugar

1 lb (4 sticks) of butter

5 lb (11 cups) of flour

1. For each ingredient available, determine how many cookies could be made if all of that ingredient is used up.
2. How many cookies are you going to be able to make with these ingredients? Which ingredient is going to limit how many cookies you can make? (Be ready to give an explanation of how you determined the maximum number of cookies you can make.)

**Stoichiometry Inquiry Activity Team #: \_\_\_\_\_\_\_**

**Chemistry Group Members: (Per: \_\_\_\_\_\_\_\_\_)**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Background:**

In chemistry, a balanced equation represents the molar quantities of reactants and products required for a complete chemical reaction. On both sides of the equation, there are the same numbers of atoms, combined in different ways to form the different compounds. The equation shows exactly what is needed for one “set” of reactions to form one “set” of products.

The situation is not always this clear and simple. Most of the time, when chemical reactions occur, there are not the precise amounts of reactants to form the products. The amount of one of the reactants “limits” the number of products that can be formed. There may be enough of one reactant to form more of the product, but no additional product can be produced without more of a second reactant.

Understanding limiting reactants allows chemists (and chefs, bakers, caterers, moms and dads making dinner) to calculate how much product they can expect from given amounts of reactants. Many variables, such as temperature and other environmental factors, can affect the yield of a chemical reaction, but by appreciating what the expected yield of a chemical reaction can be, chemists can determine if the reaction, especially in industrial situations, is profitable.

In this activity, you will model a balanced equation for a chemical reaction involving real or “alien” compounds as reactants and products. You will then use the model to illustrate the concept of a limiting reactant.

**Objectives:**

* Design a method of communicating, through a three-dimensional representation, reaction stoichiometry and a balanced equation with a limiting reactant.
* Invent simple molecules to represent reactions and products
* Construct models of molecules in appropriate proportions to represent a balanced equation with an excess reactant.
* Deduce the balanced equation invented by a different team, based on their models of reactant compound molecules and product compound molecules, and identify the limiting reactant.

**Materials:**

* Miniature marshmallows (could use Dots candies)
* Assorted Sharpies (for color marking the marshmallows)
* Toothpicks or wooden skewers

**Procedure:**

1. Discuss with your group members methods for creating models of compounds and a model for a balanced equation of invented reactants and products.
2. Create names and written symbols for your invented reactants and products to mirror the three-dimensional models you intend to build.
3. Write your invented balanced equation, identifying the components you will use in your models to represent the reactants and products.
4. Decide which reactant will be the limited reactant, and how much of all the invented compounds you will build.
5. Collect the materials you will need to create your models.
   1. Collect enough materials to create more reactant molecules than product molecules, in a proportion that allows one reactant to serve as a limiting reactant.
   2. You may decide to create more than one set of product molecules, as long as the quantity is possible given the quantity of reactant molecules you build.
6. Build your models according to your plan.
7. Have your teacher examine your balanced equation and models and then approve them as appropriately representing your alien compound reaction. When approved, record your information in the space provided below.
8. Label your collection of reactants and products, including, but not labeling, the excess reactants, and identifying both the reactants and products. Also, label your collection with your Team Number. Then exchange your collection with that of a different group.
9. Examine and analyze the collection of reactants and products given to you by the other group. Determine and write the invented balanced equation that is represented. Identify the limiting reactant. Be sure and identify the Team Number of the group that you are examining. Record your information in the space provided below.

**Your Team Information:**

* Balanced equation:
* Sketch of your model:
* Limiting reactant:
* Number of excess reactant molecules left over:

**Other Team Information:**

* Balanced equation:
* Sketch of the model:
* Limiting reactant:
* Number of excess molecules left over: