Lesson Summary

This lesson contains four activities designed to help students better understand limiting reactants. Following a teacher demonstration on the technology and procedures, students use simulations to create submicroscopic sketches, balance equations, and identify limiting reactants with supporting evidence. The final activity guides students through the process of balancing, conversions, and identifying the limiting reactants using written steps and graphs from the simulations. Students use static screen shots to complete limiting reactant problems as independent practice.

SWBAT (Student will be able to)

- Understand what limiting reactants are and how they influence a chemical reaction
- Understand how to calculate the limiting and excess reactants

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

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CCC Reminder

- Show all your work on calculations. Label all numbers. These steps will make checking work easier.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Sketches have been provided from simulations. Use the sketches as you would your own drawings.
- Make sure you understand how to convert mass to moles as well as calculate molar mass.
- Ions are charged particles that show up with a grey halo in the simulations. Ions make up ionic compounds. Use the periodic table to determine the charge of an ion.

Notes

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Homework

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Upcoming Quizzes / Tests

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Activity 1: Connecting

A teenager is babysitting for a child in the family. To keep the young child occupied, the teenager pulls out Legos® to help the child build cars. In the bucket of Legos there are 13 axles and 7 bodies.

1. Each car needs two axles and one body for the car to function. How many complete cars can the child build?

2. What part of the car has “limited” the child’s ability to make more functional cars? How did you make your choice?

3. A group of friends come home after school and want a snack. They have 3 chocolate bars, 5 marshmallows, and 12 graham crackers. A complete snack contains: 1 marshmallow, half of a chocolate bar, and 2 graham crackers. How many complete snacks can this group of friends make?

4. What ingredient “limited” the friends’ ability to make more complete snacks? How did you make your choice?

Chemical reactions are similar to the above situations. Reactions often contain reactants that limit how much products can be produced. These reactants are called limiting reactants. Recall the simulation that modeled the synthesis of sodium chloride from Lesson 2. One chlorine molecule collided with two atoms of solid sodium to form one formula unit of sodium chloride. In the simulation, there were three molecules of chlorine gas left without any sodium atoms to have a collision. The sodium was the limiting reactant in this scenario.

Reactants that do not limit the reaction and are still present when the reaction is complete are called excess reactants. In the example described above, the chlorine is an excess reactant. When one of the reactants has formed the compound before the others, no more products can be formed. If you were to add more sodium to the
simulation, the remaining chlorines would be able to react to form sodium chloride.

For example, adding vinegar to baking soda will yield a chemical reaction. If a small amount of baking soda is added to a large amount of vinegar, the reaction happens until the small amount of baking soda is completely consumed, and some vinegar will be left over. Baking soda is the limiting reactant because if more baking soda is added the reaction continues. The limiting reactant in this reaction can be identified macroscopically. The reaction on a macroscopic level is similar to how you identified what limited the Legos® and the snacks. Scientists also use mathematical calculations using experimental data to more accurately predict not only what substance is the limiting reactant, but also the amount of product that will form based on the amount of limiting reactant available. These calculations are central to stoichiometry, which involves the analysis of the relative quantities of substances involved in a chemical reaction.

Activity 2: Limiting and Excess Reactants Demonstration

Part 1

The **limiting reactant** is the reactant in a chemical reaction that limits the amount of product that can be formed. The reaction will stop when all of the limiting reactant is consumed. The **excess reactant** is the reactant in a chemical reaction that remains when a reaction stops after the limiting reactant is completely consumed. The excess reactant remains because there is nothing with which it can react. If there is only a limited amount of one reactant available for a reaction, the reaction will stop when that reactant is consumed whether or not the other reactant has been used up.

5. Using pictures of the reactants and products from the submicroscopic simulation, how could the limiting reactant and the excess reactant be identified after the reaction has occurred?

6. How do you represent excess reactants in a chemical equation?

7. Using the graphs for the reactions, how could the limiting reactant and excess reactant be identified after the reaction?
Part 2

Follow your teacher’s demonstration to use the following pictures to label the limiting reactant and excess reactants in the submicroscopic picture, determine the reaction type, and indicate the reactants and products in the space provided. Also indicate the states of matter for each reactant and product.

### Key

- **Green** Chlorine
- **Blue** Aluminum

### Graph

- **Al**
- **Cl₂**
- **AlCl₃**

<table>
<thead>
<tr>
<th>Limiting Reactant</th>
<th>Excess Reactant</th>
<th>Products</th>
<th>Reaction Type</th>
</tr>
</thead>
</table>
8. Write out the balanced chemical equation using the screen shots. Remember to include the phases of the reactants and products.

9. What is the limiting reactant for the reaction? Support your claim with evidence using your sketches.

10. Identify one additional piece of evidence from the information provided that would support your answer for the limiting reactant.

Lesson Reflection Questions

Follow your teacher's demonstration to use the following pictures to label the limiting reactant and excess reactants in the submicroscopic picture, determine the reaction type, and indicate the reactants and products in the space provided. Also indicate the states of matter for each reactant and product.

![Picture of reaction at submicroscopic level; Before (at time 0 seconds)](image)

![Picture of reaction at submicroscopic level; After (at time 30 seconds)](image)

Key

- Carbon
- Oxygen
- Hydrogen
11. Write out the balanced chemical equation using the screen shots. Remember to include the phases of the reactants and products.

12. What is the limiting reactant for the reaction? Support your claim with evidence using your sketches.

13. Identify one additional piece of evidence from the information provided that would support your answer for the limiting reactant.
Part 3

Follow your teacher’s demonstration to use the following pictures to label the limiting reactant and excess reactants in the submicroscopic picture, determine the reaction type, and indicate the reactants and products in the space provided. Also indicate the states of matter for each reactant and product.

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![Picture of reaction at submicroscopic level; Before (at time 0 seconds)](image1)

![Picture of reaction at submicroscopic level; After (at time 30 seconds)](image2)

**Key**

- Oxygen
- Hydrogen
- Chloride
- Manganese (IV) Ion
- Oxygen Ion
- Hydrogen Ion

![Graph showing mass vs. time for different substances](image3)
14. Write out the balanced chemical equation using the screen shots. Remember to include the phases of the reactants and products.

15. What is the limiting reactant for the reaction? Support your claim with evidence using your sketches.

16. Identify one additional piece of evidence from the information provided that would support your answer for the limiting reactant.

Activity 3: Calculating Limiting and Excess Reactants

Part 1

Use the graph below to answer the following questions.
17. What are the reactants in this reaction?

18. How much of each reactant did you start with?

19. How much of the limiting reactant is left?

20. How much of the excess reactant is left?

21. What are the products?

22. How much of each of the products was formed?

23. Was mass conserved in the reaction? *Support your claim with evidence.*
Part 2: Use the graph to answer the following questions.

24. What are the reactants?

25. How much of each reactant did you start with?

26. How much of the limiting reactant is left?

27. How much of the excess reactant is left?

28. What are the products?

29. How much of each of the products was formed?
30. Was mass conserved in the reaction? *Support your claim with evidence.*


**Part 3**

*Using the equations from the static pictures in Activity 2 -3 ([starting on page 49](#)), answer the following questions. For an example of how to calculate limiting and excess reactant look in Student Appendix A in the back of the book.*

*Note that the limiting reactant may be different than it was in the pictures.*

31. If 6 grams of Al is reacted with 10 grams of Cl₂, what is the limiting reactant and how much AlCl₃ is produced?

\[ 2 \text{ Al} (s) + 3 \text{ Cl}_2 (g) \rightarrow 2 \text{ AlCl}_3 (s) \]
32. If 11g C₄H₈ is reacted with 25g O₂, what is the limiting reactant and how much CO₂ is formed?

\[ C₄H₈ (g) + 6 O₂ (g) \rightarrow 4 CO₂ (g) + 4 H₂O (g) \]

33. If 2.7 g of MnO₂ is reacted with 2.7 g HCl, what is the limiting reactant and how much Cl₂ is formed?

Note: The unbalanced equation from Activity 2, Part 3, Question 14 (page 54) is:

\[ MnO₂ (s) + HCl (aq) \rightarrow MnCl₂ (aq) + H₂O (l) + Cl₂ (g) \]