Reaction Lab Worksheet

Limiting reactants, theoretical yield, and percent yield · Logical Home Schooling

Name: _____ **Date:** _____ **Period:** _____

In this lab you will use Reaction Lab to find out what limits how much product a reaction can make. You will start with a s'mores recipe, watch molecules react in a flask, solve limiting-reactant problems from grams, and calculate percent yield from experiments.

Link: www.logicalhomeschooling.com/reaction-lab.html

Objectives

By the end of this lab you will be able to:

- Explain what limiting and excess reactants are.
- Use the coefficients of a balanced equation to predict how much product forms and how much reactant is left over.
- Find the limiting reactant from masses in grams and calculate the theoretical yield.
- Calculate percent yield and explain why real yields differ from theoretical yields.

Materials: a computer or tablet with Reaction Lab open, a calculator, a pencil, this worksheet. Time: about 50 minutes.

Key ideas. The **limiting reactant** runs out first and decides how much product forms. The **excess reactant** is left over. The **theoretical yield** is the most product the math allows. percent yield = actual yield ÷ theoretical yield × 100%

Part 1: Pre-lab

1. A sandwich needs 2 slices of bread and 1 slice of cheese. You have 10 slices of bread and 3 slices of cheese. How many sandwiches can you make, and what is left over?

2. In the equation $2H_2 + O_2 \rightarrow 2H_2O$, what do the coefficients 2, 1, and 2 tell you?

Part 2: Stage 1, The s'mores problem

Recipe: 2 graham crackers + 1 marshmallow + 1 chocolate piece → 1 s'more. For each tray, work out how many s'mores each ingredient alone could make, then make the s'mores in the lab.

Tray	S'mores each ingredient could make			S'mores made	Limiting ingredient	Left over (excess)
	Graham ÷ 2	Marshmallows	Chocolate			
1: 8 G, 5 M, 6 C						
2: 10 G, 3 M, 6 C						
3: 12 G, 7 M, 4 C						
4: 14 G, 9 M, 8 C						

1. On tray 4 you had more graham crackers than anything else, but they still ran out first. Explain why.

2. In your own words, what is a limiting reactant? What is an excess reactant?

Part 3: Stage 2, The reaction flask

Predict first, then run each reaction and record what happened.

Reaction	Molecules at the start	Reactions possible from each reactant	Limiting reactant	Product molecules formed	Left over
$2H_2 + O_2 \rightarrow 2H_2O$	6 H_2, 5 O_2				
$N_2 + 3H_2 \rightarrow 2NH_3$	4 N_2, 9 H_2				
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	5 CH_4, 6 O_2				

1. In the $N_2 + 3H_2$ reaction you started with more H_2 molecules than N_2, but H_2 ran out first. Why?

2. Why did each reaction stop even though molecules of one reactant were still in the flask?

3. **Perfect mix:** How many CH_4 and O_2 molecules did you need to make exactly 6 H_2O with nothing left over? Why does that mix leave no leftovers?

Part 4: Stage 3, Limiting reactant from grams

Record each value as you solve it in the lab. Round to 4 significant figures.

Reaction and masses	Moles of reactant 1	Moles of reactant 2	Moles of product from reactant 1	Moles of product from reactant 2	Limiting reactant	Theoretical yield (g)
$2H_2 + O_2 \rightarrow 2H_2O$ 10.0 g H_2, 64.0 g O_2						
$N_2 + 3H_2 \rightarrow 2NH_3$ 28.0 g N_2, 9.00 g H_2						
$2Na + Cl_2 \rightarrow 2NaCl$ 50.0 g Na, 50.0 g Cl_2						
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ 16.0 g CH_4, 48.0 g O_2 (product: CO_2)						
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ 100. g Fe_2O_3, 60.0 g CO (product: Fe)						

Challenge: Grams of CH_4 left over: _____ Grams of CO left over: _____

1. In the sodium problem you started with equal masses of Na and Cl_2. Why didn't they run out at the same time?

2. Show every step of the Fe_2O_3 + CO problem, with units, from grams of each reactant to grams of iron.

Part 5: Stage 4, Percent yield

Experiment	Mass of reactant (g)	Theoretical yield (g)	Actual yield (g)	Percent yield	Reason the yield was not 100%
Burn magnesium → MgO	2.43				
Heat limestone → CaO	10.0				
Make a precipitate → AgCl	3.40				
Make aspirin → $C_9H_8O_4$	2.00				

1. The AgCl experiment gave a percent yield over 100%. Why is that impossible for pure, dry product? What went wrong?

2. Give two reasons a real experiment usually collects less than the theoretical yield.

Part 6: Practice problems

Answer these **without** Reaction Lab. Show your work and units.

1. For $N_2 + 3H_2 \rightarrow 2NH_3$, a container holds 5 N_2 molecules and 12 H_2 molecules. Which is limiting? How many NH_3 molecules form, and what is left over?

2. For $2H_2 + O_2 \rightarrow 2H_2O$, you react 4.00 g of H_2 with 16.0 g of O_2. Which is the limiting reactant, and what is the theoretical yield of water in grams?

3. For $Zn + 2HCl \rightarrow ZnCl_2 + H_2$, you react 10.0 g of zinc with 10.0 g of HCl. Which is limiting, and how many grams of H_2 can form? (Molar masses: Zn 65.38, HCl 36.46, H_2 2.02 g/mol.)

4. In problem 2, a student actually collects 15.3 g of water. What is the percent yield?

5. Chemists often add extra of the cheaper reactant on purpose, such as extra air (oxygen) when burning a fuel. Why might they choose to put one reactant in excess?

Conclusion

Write 3 to 5 sentences explaining how to find the limiting reactant and why it controls the amount of product. Use the words **limiting reactant**, **excess reactant**, **mole ratio**, and **theoretical yield**.