

INTRODUCTION

Chemical reactions occur when a certain number of reactants react with a certain number of another reactant (given as coefficients in the balanced equation). We can use this information to determine the mass of reactants needed, and the mass of products formed if we know the average masses of the species involved. This is called stoichiometry. In this activity, you will consider the ideas of stoichiometry with nuts and bolts.

PROCEDURE

You have a cup with some nuts and bolts. The product that you are to make consists of two nuts on each bolt. Your goal is to make as many of the product as possible.

Each set: 8 bolts, 14 nuts

LAB QUESTIONS

1. Using **N** to symbolize the nuts and **B** to symbolize the bolts, write out an equation for the formation of the product and justify your answer. Make an analogy with chemical equations and pay attention to the difference between a coefficient and a subscript.



2. How many nuts did you have? **14** How many bolts? **8**
3. How many of the products could you make? **7**
4. Which reactant (nut or bolt) was limiting? **nuts** How did you determine this? Is it the reactant you had fewer of? Why or why not?
5. How much of which reactant did you have left over? **1 bolt** How did you determine this?
6. Why does there have to be something left over in this case? That is, why couldn't you just make a product with fewer or more nuts? How does this relate to balancing a chemical equation?

Given that the average mass of a bolt is 10.64 g and the average mass of a nut is 4.35 g, answer the following questions:

7. What is the mass of all the bolts you were given? **85.12 g** Mass of all nuts? **60.9 g**
8. What is the mass of one product? **19.34 g**
What is the mass of all the products that you formed? **135.38 g**
9. What is the mass of the left over reactant? **10.64 g**
10. Given the mass of bolts you had, calculate the mass of the nuts you would need to use up all of the bolts. **16 bolts x 4.35 g/bolt = 69.6 g**
11. Given the mass of nuts you had, calculate the mass of the bolts you would need to use up all of the nuts. **7 bolts x 10.64 g/bolt = 74.48 g**

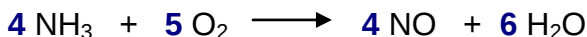
Friends of yours give you what they say is “about 1000 g” of nuts and “about 1000 g” of bolts. Answer the following questions: (show work for full credit)

12. How many nuts were you given? **230 nuts** How many bolts? **94 bolts**
13. Which reactant is limiting? **bolts** Why is one limiting if you have equal masses of each? **You need 2x as many nuts as bolts.**
14. What is the mass of the product you could make? **1817.96 g** How many is this? **94**
 $(94 \text{ B})(10.64 \text{ g/bolt}) + (188 \text{ N})(4.35 \text{ g/nut}) = 1817.96$
15. How many of which reactant is left over? **42 nuts** $(230 - 188 = 42)$
 What is the mass of left over reactant? **182.7 g** $(42 \text{ nuts})(4.35 \text{ g/nut}) = 182.7 \text{ g}$
16. Given the mass of excess reactant (calculated in question 15), calculate the mass of the bolts you would need to use up all the nuts. **223.44 g**
 $42 \text{ nuts} / 2 = 21 \text{ bolts}$ $(21 \text{ bolts})(10.64 \text{ g/bolt}) = 223.44 \text{ g of bolts}$
17. Given the mass of bolts you had, calculate the mass of the nuts you would need to use up all of the bolts. **817.8 g** $(188 \text{ nuts})(4.35 \text{ g/nut}) = 817.8 \text{ g of nuts}$

ADDITIONAL QUESTIONS (Post-lab)

1. An individual coefficient in a balanced equation is meaningless. Why?
Coefficients give a ratio of reactants and products. Knowing a single number doesn't tell you how much of anything else you need. It's like knowing a single number to a lock with three numbers (you ain't going to get the lock open!)

2. Consider the reaction represented by the (unbalanced) equation.



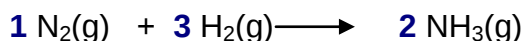
For every 1.00 mol of NH_3 that reacts, $\frac{5}{4}$ mol of O_2 is required. (show work)

$$x \text{ mol O}_2 = 1.00 \text{ mol NH}_3 \left(\frac{5 \text{ mol O}_2}{4 \text{ mol NH}_3} \right) = 1.25 \text{ mol O}_2 \quad \textbf{1.25 mol of O}_2$$

3. Which would produce a greater number of moles of product: a certain amount of hydrogen gas reacting with oxygen to make water, or the same amount of hydrogen gas reacting with nitrogen gas to make ammonia? Show your work.

Formation of water would produce greater moles of product.
See attached sheet

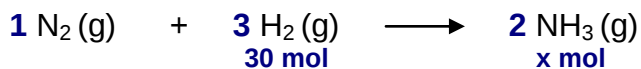
4. Considering the reaction represented by the (unbalanced) equation



Determine the number of moles of $\text{NH}_3(\text{g})$ that can be produced from the following:

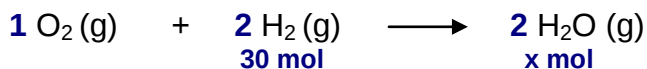
- a) 0.20 mol $\text{N}_2(\text{g})$ reacts completely with $\text{H}_2(\text{g})$ **0.4 mol NH_3**
 (work on attached sheet)
- b) 0.30 mol $\text{H}_2(\text{g})$ reacts completely with $\text{N}_2(\text{g})$ **0.10 mol NH_3**

3. Which would produce a greater number of moles of product: a certain amount of hydrogen gas reacting with oxygen to make water, or the same amount of hydrogen gas reacting with nitrogen gas to make ammonia? Show your work.



*Pick any amount of hydrogen to begin with. I chose **30 mole** to make the math simple.*

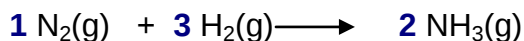
$$x \text{ mol NH}_3 = 30 \text{ mol H}_2 \left(\frac{2 \text{ mol NH}_3}{3 \text{ mol H}_2} \right) = 20 \text{ mol NH}_3$$



$$x \text{ mol H}_2\text{O} = 30 \text{ mol H}_2 \left(\frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol H}_2} \right) = 30 \text{ mol H}_2\text{O}$$

Therefore, you would make more product making the WATER.

4. Considering the reaction represented by the (unbalanced) equation



Determine the number of moles of $\text{NH}_3(\text{g})$ that can be produced from the following:

- a. 0.20 mol $\text{N}_2(\text{g})$ reacts completely with $\text{H}_2(\text{g})$ **0.4 mol NH_3**

$$x \text{ mol NH}_3 = 0.20 \text{ mol N}_2 \left(\frac{2 \text{ mol NH}_3}{1 \text{ mol N}_2} \right) = 0.40 \text{ mol NH}_3$$

- b. 0.30 mol $\text{H}_2(\text{g})$ reacts completely with $\text{N}_2(\text{g})$ **0.10 mol NH_3**

$$x \text{ mol NH}_3 = 0.30 \text{ mol H}_2 \left(\frac{1 \text{ mol N}_2}{3 \text{ mol H}_2} \right) = 0.10 \text{ mol N}_2$$