

Stoichiometry Mole to Mole Problems

Today we will take our equation writing one step further to equation calculations. Basically, we will be calculating the amount of product produced from a given amount of reactant. This quantitative study of the relationship between reactants and products is known as stoichiometry (stoy-key-ah-meh-tree).

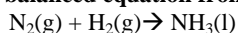
We will begin our study of stoichiometry with the most basic of problems, mole-to-mole calculations. Later we will expand our study to mass-to-mass, volume-to-volume, volume to mass and mass to volume calculations. Once we have mastered these problems, we will learn to calculate limiting reactant and percent yield problems. In limiting reactant problems we will identify which reactant will restrict the amount of product produced. In percent yield problems we will compare lab results with theoretical results in order to measure lab efficiency.

For our study of stoichiometry we will use the chart printed below. It is also on the back of your periodic table.

The best way to understand how to use this chart is with an example. As I wrote earlier, we will focus on mole-to-mole problems today.

Example #1: Nitrogen gas reacts with hydrogen gas to produce liquid ammonia, NH_3 . Calculate the number of moles of ammonia produced from 9.5 moles of nitrogen gas and an unlimited supply of hydrogen gas.

Step 1: Write the balanced equation from the given information.



Don't forget nitrogen and hydrogen are diatomic. As far as the (g) & (l), since it was stated in the problem, write it. It will be important later. Not all problems will give you the state of the elements and compounds. But if it is given, write it.

Balanced: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{l})$

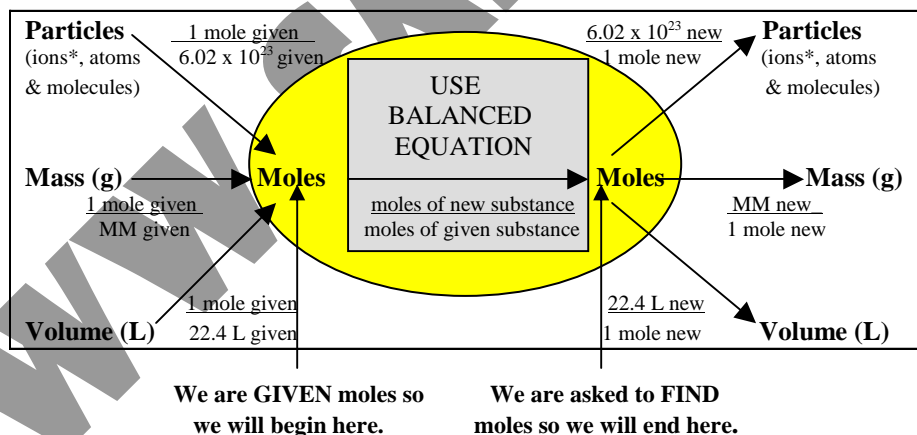
Step 2: Determine and write what you are GIVEN. Hint: This will ALWAYS be a number, a unit and a formula (or name of a molecule).

GIVEN: 9.5 moles of nitrogen, N_2 .

Step 3: Determine and record what you are asked to find.

FIND: moles of ammonia, NH_3 .

Step 4: Using your chart, determine the starting and ending point of your calculation. Also, determine the number of steps in the problem. (Hint: Each bold term (particles, mass, volume & moles) represents a step.) You will ALWAYS begin on the left half of the chart and finish on the right half of the chart.

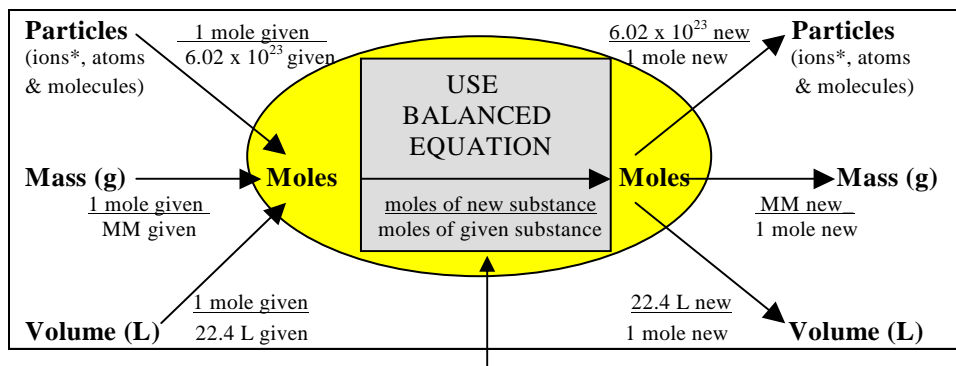


Since we will start at **Moles** and end at **Moles** and use only two bold terms in the path from one to the other, our problem will have two steps. (All mole-to-mole problems will have only two steps.)

Step 5: Write your GIVEN value (number, unit & formula) over one.

$\frac{9.5 \text{ moles of N}_2}{1}$

Step 6: Using the chart, MULTIPLY the GIVEN by the ratio for that step.



Since we are going from moles to moles, we must use the balanced equation and put the moles of the new substance over the moles of the given.

Look at the balanced equation below. There are **two moles of the new substance, NH₃**, and **one mole of the GIVEN substance, N₂**.

$$\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$$

Thus:

$$\frac{9.5 \text{ moles of N}_2}{1} \times \frac{2 \text{ moles of NH}_3}{1 \text{ mole of N}_2} =$$

Your set-up should always be such that if a unit & formula are on top of the ratio in one step, they must be on the bottom in the next. You will always cancel out units and formulas in successive steps. In our problem, **moles of N₂** is on the top in the first step and on the bottom in the next. So, we can cancel the units and formula.

$$\frac{9.5 \text{ moles of N}_2}{1} \times \frac{2 \text{ moles of NH}_3}{1 \text{ mole of N}_2} =$$

Step 7: Calculate your answer by multiplying straight across. Your answer must have a number, units and a formula. The units and formula of your answer will be the only one not crossed out. All calculations should have the correct number of significant figures. The numbers used from balancing the equation are not used to determine significant figures.

$$\frac{9.5 \text{ moles of N}_2}{1} \times \frac{2 \text{ moles of NH}_3}{1 \text{ mole of N}_2} = \frac{19 \text{ moles of NH}_3}{1} = 19 \text{ moles of NH}_3$$

Summary of how to calculate a mole-to-mole problem:

$$\frac{\text{GIVEN}}{1} \times \frac{\text{moles of new substance from equation}}{\text{moles of given substance from equation}} =$$

Homework: Do these on a separate sheet of paper.

- Glucose, C₆H₁₂O₆, reacts with oxygen to produce carbon dioxide, CO₂, and water. If I give Pilar 17.5 moles of glucose and an unlimited supply of oxygen, how many moles of carbon dioxide can she produce?
- Aluminum reacts with oxygen to produce aluminum oxide. If I give Tanya 43.2 moles of aluminum and she has an unlimited supply of oxygen, how many moles of aluminum oxide can she make me?
- Hydrogen gas reacts with oxygen gas to produce liquid water. How many moles of water can Jill produce if she has 42.0 moles of hydrogen gas and an unlimited supply of oxygen gas?
- Ferric oxide (rust) is produced through the synthesis of iron and oxygen. If Michelle is given 6.9 moles of iron and an unlimited supply of oxygen, how many moles of rust can she make?
- Aluminum hydroxide reacts with hydrogen sulfate. Assume that Lulu has 73.2 moles of aluminum hydroxide and an unlimited supply of hydrogen sulfate. Calculate the amount of moles of each product Lulu can produce.
- Hydrogen chloride gas reacts with oxygen gas to produce water vapor (gas) and chlorine gas. Joan has to produce 13.3 moles of chlorine gas for Dr. Ellen. How many moles of hydrogen chloride does she need to purchase in order to make the desired amount of chlorine gas?
- Aqueous silver nitrate reacts with aqueous barium chloride. Determine the products of this reaction. If Amy has an unlimited supply of silver nitrate and 18.1 moles of barium chloride, calculate the amount of moles of the insoluble product she can produce. (Hint: Use your solubility chart on the back of your periodic table.)