

## Stoichiometric Calculations

The ability to balance and interpret equations enable us to make calculations involving masses of substances involved in the reaction. This involves understanding mass, mole, and volume. Stoichiometry is the study of quantitative relationships involved in chemical reactions.

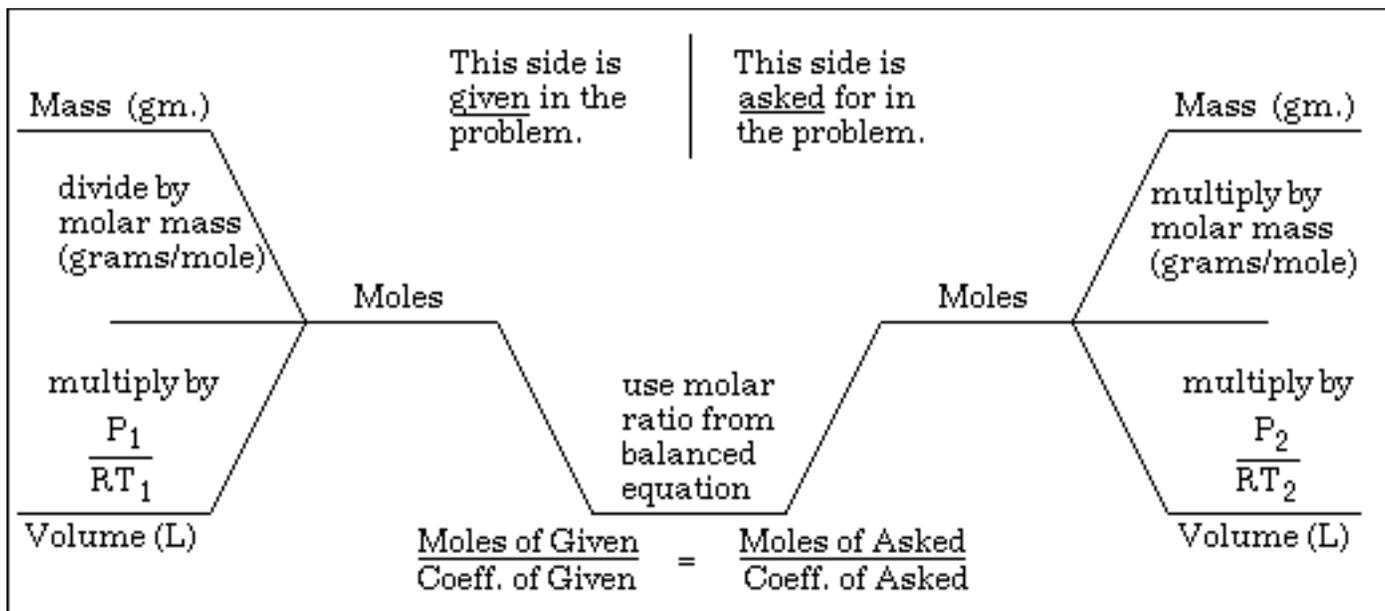
There are two categories of stoichiometric problems you will be expected to be able to solve.

1. One deals with moles only. For example, a problem might say: Given this reaction:  $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$  and excess hydrogen, 1.50 moles of oxygen gas will produce how many moles of water? Answer = 3.00 moles
2. The second deals with grams. For example, a problem might say: Given the reaction:  $2 \text{H}_2\text{S} + 3 \text{O}_2 \rightarrow 2 \text{H}_2\text{O} + 2 \text{SO}_2$ ; 24.0 grams of oxygen will react completely with how many grams of hydrogen sulfide?

### Before We Start

Look at the equation in No. 2 just above. It is important to realize that this equation can be understood two different ways. First, it can be understood to mean that two molecules of hydrogen sulfide react with three molecules of oxygen gas to produce two molecules of water and two molecules of sulfur dioxide. Second, IT CAN ALSO be understood in terms of moles. The same 2:3:2:2 sequence applies, only now it is moles and not molecules.

### A Pattern for Stoichiometric Calculations



### How to Read the Chart

Start on the left side with whatever you have been given in the problem. Please note that you must read the problem, you cannot solve the problem without reading it. Stoichiometric problems will give you grams, moles, or volume of a substance. Perform the appropriate calculations to give you moles of the substance. Then, you must construct a proportion using the various values. Note that the "Moles of Asked" above will be where the unknown (signified by 'x') is located. Once you have determined the moles of your unknown (the substance asked for), you can convert it to grams or volume, depending on what the problem has asked for. Occasionally, the problem will simply ask for the moles, in which case you do not have to convert. Please note that sometimes the next problem might be a continuation asking you for grams or volume. In the chart above 'L' stands for liters.

You MUST convert to moles first. Do this by dividing by the appropriate molar mass. If your problem gives you moles already, then skip this step completely. The problem may specify grams of reactant or product, it makes no difference. Generally, if given a reactant you could be asked for how much product or how much of another reactant will be needed.

You MUST have a correctly balanced equation. Be sure of this, for an incorrect equation will throw everything off from this point on. In this step, you will be working with 2 ratios (when set equal, they will make a proportion). The first ratio has both numbers coming from coefficients in the balanced equation. For example:  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ . The ratio between hydrogen and oxygen is 2:1. The ratio between hydrogen and water is 2:2 (or 1:1, it will make no difference in the final answer if you don't use the lowest ratio). Note that this ratio is selected on the basis of which substances are discussed in the problem. The second ratio uses numbers from the problem. One of the numbers in this ratio will be 'x', the unknown value we are solving for. The other number in this ratio will be the number of moles just computed. Set the two ratios equal to one another and solve. One very important warning, numbers which represent the same substance in each ratio MUST both be on top or on bottom. The exact side is not important, the fact that they are both on the same side is.

After you solve the proportion, you have what 'x' equals. What does this number represent? It is the number of moles of the substance you are being asked about that are involved. (Did that make sense?) If you are being asked for moles in your answer, then stop. If you are being asked for grams, then multiply by the proper molar mass. A very common mistake is to multiply by the molar mass used above. That is WRONG! Can you tell me why?

Please note, the coefficient of the equation will play no role in determining significant figures for your final answer. It is an exact number, with an infinite number of significant figures.

### Stoichiometry Problems

- Given the following equation:  $2\text{C}_4\text{H}_{10} + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O}$ , show what the following molar ratios should be.  
 a.  $\text{C}_4\text{H}_{10} / \text{O}_2$       b.  $\text{O}_2 / \text{CO}_2$       c.  $\text{O}_2 / \text{H}_2\text{O}$       d.  $\text{C}_4\text{H}_{10} / \text{CO}_2$       e.  $\text{C}_4\text{H}_{10} / \text{H}_2\text{O}$
- Given the following equation:  $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$       How many moles of  $\text{O}_2$  can be produced by letting 12.00 moles of  $\text{KClO}_3$  react?
- Given the following equation:  $2\text{K} + \text{Cl}_2 \rightarrow 2\text{KCl}$       How many grams of  $\text{KCl}$  is produced from 2.50 g of  $\text{K}$  and excess  $\text{Cl}_2$ . From 1.00 g of  $\text{Cl}_2$  and excess  $\text{K}$ ?
- Given the following equation:  $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$       How many grams of  $\text{NaOH}$  is produced from  $1.20 \times 10^2$  grams of  $\text{Na}_2\text{O}$ ? How many grams of  $\text{Na}_2\text{O}$  are required to produce  $1.60 \times 10^2$  grams of  $\text{NaOH}$ ?
- Given the following equation:  $8\text{Fe} + \text{S}_8 \rightarrow 8\text{FeS}$       What mass of iron is needed to react with 16.0 grams of sulfur? How many grams of  $\text{FeS}$  are produced?
- Given the following equation:  $2\text{NaClO}_3 \rightarrow 2\text{NaCl} + 3\text{O}_2$       12.00 moles of  $\text{NaClO}_3$  will produce how many grams of  $\text{O}_2$ ? How many grams of  $\text{NaCl}$  are produced when 80.0 grams of  $\text{O}_2$  are also produced?
- Given the following equation:  $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$       How many moles of  $\text{Cu}$  are needed to react with 3.50 moles of  $\text{AgNO}_3$ ? If 89.5 grams of  $\text{Ag}$  were produced, How many grams of  $\text{Cu}$  reacted?
- Molten iron and carbon monoxide are produced in a blast furnace by the reaction of iron(III) oxide and coke (pure carbon). If 25.0 kilograms of pure  $\text{Fe}_2\text{O}_3$  is used, how many kilograms of iron can be produced? The reaction is:  $\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$
- The average human requires 120.0 grams of glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) per day. How many grams of  $\text{CO}_2$  (in the photosynthesis reaction) are required for this amount of glucose? The photosynthetic reaction is:  $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
- Given the reaction:  $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{l})$       When 1.20 mole of ammonia reacts, the total number of moles of products formed is:  
 a. 1.20      b. 1.50      c. 1.80      d. 3.00      e. 12.0