ChemQuest 51

Gas Stoichiometry

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour: \_\_\_\_\_

**Information**: Mole Ratios in Chemical Equations and Volume

As you know, the coefficients in balanced equations relate the number of moles of reactants to each other. For gaseous reactions, the coefficients relate not only the moles but also the number of liters of reactants and products to each other. For example, consider the following reaction, noting that “(g)” means that the substances are gaseous:

N2 (g) + 2 O2 (g) 🡪 2 NO2 (g)

The coefficients tell you that for every mole of N2, two moles of O2 react and two moles of NO2 are produced.

\*\*It also tells you that for each liter of N2, two liters of O2 react and two liters of NO2 are produced.

**Critical Thinking Questions**

1. Consider the balanced equation in the above information section. If 3.5 L of nitrogen react, how many liters of NO2 will be produced?
2. In a certain combustion reaction involving propane, 34.4 L of CO2 was produced. How many liters of propane (C3H8) were combusted? The balanced equation is:

C3H8 (g) + 5 O2 (g) 🡪 3 CO2 (g) + 4 H2O (g)

1. Use the following balanced equation for the formation of ammonia when answering the next questions: N2 + 3 H2 🡪 2 NH3
   1. If 4.2 L of H2 react, how many liters of NH3 will be produced?
   2. If a chemist hopes to react 5 L of N2, how many liters of H2 would she need?

**Information**: Limiting Reactants

In question 3b, you saw that there were 15L of H2 needed to combine with the 5L of N2. What if the exact amount (15 L) of H2 was not available?

If we had more than 15 L of H2, then there would be too much and H2 would be called the “excess reactant” because there is an excess (too much) of hydrogen. N2 would be called the “limiting reactant” in this case.

**Critical Thinking Questions**

1. Verify that for the following reaction to be completed, 4 liters of hydrogen would require 2 liters of oxygen gas at the same pressure and temperature.

2 H2 (g) + O2 (g) 🡪 2 H2O (g)

1. Given the following balanced equation: Example: 2 N2 (g) + 5 O2 (g) 🡪 2 N2O5 (g). If 6 L of N2 react with 12 L of O2, which is the limiting reactant? Follow these steps…
   1. Hint: pick one of the liters—let’s say the 6 L of N2—and ignore the other one. Find out how many liters of O2 you would need to react with the 6 L of N2.
   2. Compare the amount from part (a) with the amount that the question says you actually have (which is 12 L). Which is greater?
   3. If the amount in the question is greater than your answer to part (a), then O2 is the excess reactant and N2 would therefore be the limiting reactant. If the amount in the question is less than your amount then O2 is the limiting reactant. So… which is the limiting reactant – N2 or O2?
2. Again consider the balanced equation given in question 5. If 3 L of N2 react with 8 L of O2, which substance is the limiting reactant?

**Information**: Finding the Liters of a Product

In question 1, you were able to calculate the liters of product produced because you were given the liters of one of the reactants. Take a look at question 1 to refresh your memory. You were given the starting liters of only ONE of the reactants. When you are given the liters of BOTH reactants (like in questions 5 and 6), you have to first find which one is the limiting reactant. Then, you use the liters for the limiting reactant to calculate the liters of the product.

**Critical Thinking Questions**

1. In question 6, you found out that nitrogen is the limiting reactant when 3 L of N2 react with 8L of O2 in this reaction: 2 N2 (g) + 5 O2 (g) 🡪 2 N2O5 (g). Use the 3 L of N2 to calculate how many liters of N2O5 are produced.
2. In producing ammonia (N2 + 3 H2 🡪 2 NH3), 5.4 L of N2 react with 14.2 L of H2. How many liters of NH3 will be produced?
   1. First find out which one—N2 or H2 is the limiting reactant.
   2. Use the liters of the limiting reactant to find out the liters of NH3 produced.
3. Why did you have to find the limiting reactant in question 8, but not in question 3?
4. 0.75 L of nitrogen react with 1.85 L of chlorine gas in the following equation. How many liters of NCl3 will be produced?

N2 + 3 Cl2 🡪 2 NCl3

**Information**: Gases and Solutions

A solution is formed when one substance dissolves in another. Salt water is perhaps the most common solution. It consists of salt dissolved in water.

Consider the following diagrams:

Pure Water A solution (something dissolved in water)

Important note: Even though it looks like the molecules are stacked neatly, please remember that the molecules are still also in motion.

**Critical Thinking Questions**

1. Compare the density of pure water and the density of a solution. Use the above diagram as a visual for what a solution is like compared to what a pure solvent is like. Which has a greater density? Why?
2. You’ve probably noticed some things about solutions. For example, consider dissolving sugar. Does sugar dissolve better in a warm or in a cold solvent?
3. Gases follow a patter opposite to that of sugar. When the water is warm, LESS gas will dissolve.
4. When the temperature of gas molecules increases, what happens to their speed?
5. “Kinetic energy” is the energy of motion. If two substances are at the same temperature, what can be said about their kinetic energy?
6. Given your answer to part a, why might gas molecules not dissolve well if the water is warm?
7. Given what you learned from question 13, consider two kinds of fish—king salmon and piranhas. Piranhas live only in tropical waters and king salmon prefer cold waters. Based on this information and your answers to the previous question, which type of fish requires water that has a lot of oxygen dissolved in it?