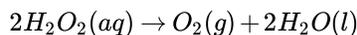


## 6.2: Molar Stoichiometry in Chemical Equations

If we were to describe the reaction of sodium metal with chlorine gas in molar terms, we would say that two *moles* of sodium metal combine with one *mole* of  $\text{Cl}_2$  to give two *moles* of sodium chloride. In terms of mass, two moles of sodium, having a total mass of 45.98 grams, would react with one mole of chlorine gas (a mass 70.90 grams) to give two moles of sodium chloride, for a total of 275.9 grams of product. Likewise, the molar stoichiometry for the decomposition of hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) to form oxygen and water, can be described simply as *two moles of  $\text{H}_2\text{O}_2$  decompose to form one mole of oxygen gas and two moles of water.*



The stoichiometric coefficients for this reaction gives us the key information about the relationship between molar quantities of reactants and products, but in the real world, we will not always be working with exactly two moles of hydrogen peroxide. What if you want to know how much oxygen gas will be formed when 0.28 moles of  $\text{H}_2\text{O}_2$  decompose? One way to solve this type of problem is to utilize a tool that we will call a *reaction pathway*. The reaction pathway is a kind of simple map of the stoichiometry of a reaction, which uses arrows to show the relationship between reactants and products.

Using the **given-find-ratio** algorithm that we introduced back in [Chapter 1](#), if we were given *mol reactant* and we wanted to find *mol product*, we could set up a simple equation as follows:

$$(\text{mol product}) = (\text{mol reactant}) \left( \frac{\text{mol product}}{\text{mol reactant}} \right)$$

The units *mol reactant* cancel to give the solution in *mol product*. If we were given *mol product* and we wanted to find *mol reactant*, we would set up the equation as follows in order for the units to properly cancel:

$$(\text{mol reactant}) = (\text{mol product}) \left( \frac{\text{mol reactant}}{\text{mol product}} \right)$$

This basic approach can be used to solve for any molar (mass, or gas) conversion based on a balanced chemical equation, as long as you are careful to set up the ratios so that the units cancel, giving you the desired solution with the proper units. As an example, return to the question of the decomposition of  $\text{H}_2\text{O}_2$ . If 0.28 moles of  $\text{H}_2\text{O}_2$  decompose, according to the equation given below, how many moles of oxygen gas ( $\text{O}_2$ ) will be formed?

$$\left( \frac{1 \text{ mol } \text{O}_2}{2 \text{ mol } \text{H}_2\text{O}_2} \right)$$

We set up the problem to solve for mol product; the general equation is:

$$(\text{mol product}) = (\text{mol reactant}) \left( \frac{\text{mol product}}{\text{mol reactant}} \right)$$

The stoichiometric mole ratio is set up so that *mol reactant* will cancel, giving a solution in *mol product*. Substituting,

$$(x \text{ mol } \text{O}_2) = (0.28 \text{ mol } \text{H}_2\text{O}_2) \times \left( \frac{1 \text{ mol } \text{O}_2}{2 \text{ mol } \text{H}_2\text{O}_2} \right) = 0.14 \text{ mol } \text{O}_2$$

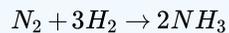
Thus, the decomposition of 0.28 mol of  $\text{H}_2\text{O}_2$  will produce 0.14 mol of the product, oxygen gas ( $\text{O}_2$ ).

### ? Exercise 6.2.1

- Iron (III) oxide reacts with hydrogen gas to form elemental iron and water, according to the balanced equation shown below. How many moles of iron will be formed from the reduction of excess iron (III) oxide by 0.58 moles of hydrogen gas?
- When an impure sample containing an unknown amount of  $\text{Fe}_2\text{O}_3$  is reacted with *excess* hydrogen gas, 0.16 moles of solid Fe are formed. How many moles of  $\text{Fe}_2\text{O}_3$  were in the original sample?

### ? Exercise 6.2.2

Ammonia is produced industrially from nitrogen and hydrogen according to the equation:



- If you are given 6.2 moles of nitrogen how many mole of ammonia could you produce?
- How many moles of hydrogen would you need to fully react with 6.2 moles of nitrogen?
- If you wished to produce 11 moles of ammonia how many moles of nitrogen would you need to start with?

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