

Stoichiometry Word Problems 1 - SOLUTIONS



1. The emergency airbags in modern automobiles use a rapid chemical reaction to fill the bag in the case of an accident. Sodium azide (NaN_3) reacts with potassium nitrate to rapidly produce nitrogen gas, potassium oxide, and sodium oxide. The balanced (you're welcome) reaction is as follows:

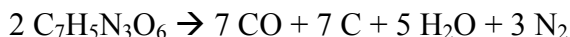


The driver's side airbag in a GMC Yukon is approximately 63.2 liters when fully inflated. Assuming the nitrogen gas is at STP (it's not, actually), what masses of sodium azide and potassium nitrate are necessary to inflate the airbag?

$$\text{For } \text{NaN}_3: \left(\frac{63.2 \text{ L } \text{N}_2}{1} \right) \left(\frac{1 \text{ mol } \text{N}_2}{22.4 \text{ L } \text{N}_2} \right) \left(\frac{10 \text{ mol } \text{NaN}_3}{16 \text{ mol } \text{N}_2} \right) \left(\frac{65.0 \text{ g } \text{NaN}_3}{1 \text{ mol } \text{NaN}_3} \right) = 114.6 \text{ g } \text{NaN}_3$$

$$\text{For } \text{KNO}_3: \left(\frac{63.2 \text{ L } \text{N}_2}{1} \right) \left(\frac{1 \text{ mol } \text{N}_2}{22.4 \text{ L } \text{N}_2} \right) \left(\frac{2 \text{ mol } \text{KNO}_3}{16 \text{ mol } \text{N}_2} \right) \left(\frac{101.1 \text{ g } \text{KNO}_3}{1 \text{ mol } \text{KNO}_3} \right) = 35.7 \text{ g } \text{KNO}_3$$

2. The explosive known as TNT (trinitrotoluene) is very useful because it works without the presence of a separate oxidizer. Basically, all of the energy is stored in the TNT, so the explosion can occur even if there is no oxygen present. The explosion of TNT is a decomposition reaction:



A forensic chemist who happens to be exceptionally good at his job is investigating the site of a TNT blast and is able to determine that there are 351 grams of carbon residue left by the explosion. How many grams of TNT were used for the explosion?

$$\left(\frac{351.0 \text{ g } \text{C}}{1} \right) \left(\frac{1 \text{ mol } \text{C}}{12.0 \text{ g } \text{C}} \right) \left(\frac{2 \text{ mol } \text{C}_7\text{H}_5\text{N}_3\text{O}_6}{7 \text{ mol } \text{C}} \right) \left(\frac{227.1 \text{ g } \text{C}_7\text{H}_5\text{N}_3\text{O}_6}{1 \text{ mol } \text{C}_7\text{H}_5\text{N}_3\text{O}_6} \right) = 1897.9 \text{ g } \text{C}_7\text{H}_5\text{N}_3\text{O}_6$$

3. (This is a tricky one!) Coal, which is mostly carbon, is burned in power plants in the Midwestern United States. Most coal contains some sulfur (S_8) which, which is ultimately responsible for some acid rain in the eastern United States. Here's how:

- I. Sulfur burns in the presence of oxygen to create sulfur dioxide gas.
- II. Sulfur dioxide gas is converted into sulfur trioxide gas when combined with oxygen gas in a synthesis reaction known as a photooxidation (powered by the rays of the good old sun).
- III. Sulfur trioxide reacts with water vapor in the atmosphere to create sulfuric acid, which subsequently becomes aqueous in

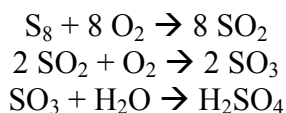


rainwater and falls to the Earth.

This carefully, and take your time: If 0.0037% by mass of all of the coal ore burned in the Midwest is actually sulfur:

a) How many *kilograms* of coal ore have to burn to generate 1 kilogram of acid?

Write three equations:



$$\left(\frac{1 \text{ kg } H_2SO_4}{1}\right)\left(\frac{1000 \text{ g } H_2SO_4}{1.0 \text{ kg } H_2SO_4}\right)\left(\frac{1 \text{ mol } H_2SO_4}{98 \text{ g } H_2SO_4}\right)\left(\frac{1 \text{ mol } SO_3}{1 \text{ mol } H_2SO_4}\right)\left(\frac{2 \text{ mol } SO_2}{2 \text{ mol } SO_3}\right)\left(\frac{1 \text{ mol } S_8}{8 \text{ mol } SO_2}\right)\left(\frac{256 \text{ g } S_8}{1 \text{ mol } S_8}\right) = 327 \text{ g } S_8$$

$$\left(\frac{327 \text{ g } S_8}{1}\right)\left(\frac{1 \text{ kg } S_8}{1000 \text{ g } S_8}\right)\left(\frac{1 \text{ kg coal ore}}{.000037 \text{ kg } S_8}\right) = 8837.84 \text{ kg coal ore}$$

b) How many liters of sulfur trioxide gas does this amount to (assume STP)?

$$\left(\frac{1 \text{ kg } H_2SO_4}{1}\right)\left(\frac{1000 \text{ g } H_2SO_4}{1.0 \text{ kg } H_2SO_4}\right)\left(\frac{1 \text{ mol } H_2SO_4}{98 \text{ g } H_2SO_4}\right)\left(\frac{1 \text{ mol } SO_3}{1 \text{ mol } H_2SO_4}\right)\left(\frac{22.4 \text{ L } SO_3}{1 \text{ mol } SO_3}\right) = 228.6 \text{ L } SO_3$$