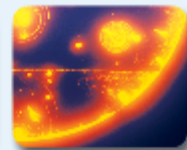
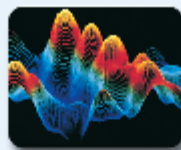


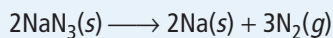
# Chemistry in Action



## Air Bags and Stoichiometry

Air bags are part of the mandatory safety systems in passenger vehicles currently sold in the United States. An air bag inflates upon collision and prevents the driver or passenger from hitting the steering wheel, dashboard, or windshield. An air bag also absorbs some of the force resulting from the collision by immediately deflating through vents when the driver or passenger hits the air bag.

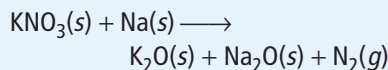
Air bags are amazing devices. They must inflate within 0.04 seconds of a collision. Because a collision cannot be predicted, the inflation system must be ready to activate at any time during the life of the vehicle. The rapid chemical decomposition of solid sodium azide,  $\text{NaN}_3$ , allows the air bag to inflate fast at any time. The decomposition reaction is initiated in a car by a small ignition induced by a collision sensing mechanism. The nitrogen gas produced during the reaction inflates the air bag. Although  $\text{NaN}_3$  is stable at room temperature, it decomposes into solid sodium and nitrogen gas at temperatures above  $300^\circ\text{C}$  by the reaction shown below.



An air bag has a fixed volume, which means that the amount of gas released has to be carefully controlled. A typical air bag contains approximately 130 g of  $\text{NaN}_3$  that can produce 67 L of  $\text{N}_2$  gas when  $\text{NaN}_3$  decomposes. If an insufficient amount of nitrogen were produced, the air bag would under inflate and

not provide adequate protection. Clearly, the stoichiometry of the reaction is very important.

The safety of the chemical products produced in air bags is also an important consideration. Sodium azide is highly toxic, but it is entirely consumed in the decomposition reaction. The sodium that is produced by the sodium azide decomposition can react explosively with water to produce sodium hydroxide and hydrogen. Potassium nitrate,  $\text{KNO}_3$ , is mixed with the sodium azide because  $\text{KNO}_3$  can react with the sodium metal to produce safer compounds, as shown in the following *unbalanced* equation:



Another chemical reaction is still required because the potassium oxide,  $\text{K}_2\text{O}$ , and sodium oxide,  $\text{Na}_2\text{O}$ , are too

reactive to be considered safe. A third ingredient, silicon dioxide,  $\text{SiO}_2$ , the main ingredient in sand, reacts with the sodium oxide and potassium oxide to form a safe, stable silicate glass. As a result, all of the harmful products generated during the air bag inflation are converted into safe substances. However, the reaction of the potassium nitrate with the sodium metal also produces nitrogen gas, which will increase the volume of gas inside the air bag. Careful stoichiometric calculations are needed to choose the correct amount of reactants to yield the total volume of nitrogen required for the air bag to function properly.

### Question

1. Balance the equation for the reaction of potassium nitrate and sodium.

▼ *An air bag inflates with nitrogen in 0.04 seconds.*



## Air Bags and Stoichiometry

**Directions:** Read the article on airbags and stoichiometry and answer the following questions.

1. What type of reaction occurs initially with sodium azide when airbags initially deploy?
2. Write the complete, balanced reaction below.
3. What would happen if the manufacturers did not start with the correct amount of sodium azide?
4. Based on the article, what is stoichiometry? Why is it important for airbag safety?
5. Why is potassium nitrate also in airbags?
6. Write the balanced equation for the reaction between potassium nitrate and sodium below.
7. What is the point of silicon dioxide?
8. Why are careful stoichiometric calculations important for air bags and safety?