## GAS LAW STOMGHOLMETBY

The molar ratios in the balanced chemical equations can be used to do many calculations.
Use the given information in the problem to calculate the number of moles.
Use the molar ratio of the balanced chemical equation to answer the problem.

## EXAMMPLE

1. In the Haber Process ammonia is produced from the reaction of hydrogen and nitrogen gases. What volume of ammonia at 450 . kPa pressure and $80^{\circ} \mathrm{C}$ can be obtained from the complete reaction of 7.5 kg of hydrogen?

$$
1 \mathbf{N}_{2}(\mathrm{~g})+\underset{\substack{3 \\
7.5 \mathrm{~kg}}}{3 \mathbf{H}_{2}(\mathrm{~g})} \quad \rightarrow \quad \begin{aligned}
& 2 \mathrm{NH}_{3}(\mathrm{~g})
\end{aligned}
$$

Convert the mass to moles

$$
\begin{aligned}
& \mathrm{n}=\mathrm{m} / \mathrm{M} \\
& \mathrm{n}=7.5 \mathrm{~kg} /(2.02 \mathrm{~g} / \mathrm{mol}) \\
& \mathrm{n}=3.7 \mathrm{kmol}
\end{aligned}
$$

Now use the molar ratio from the equation to calculate the number of moles of $\mathrm{NH}_{3}(\mathrm{~g})$

$$
\begin{aligned}
& 3.7 \mathrm{kmol} \quad \mathrm{x} 2 / 3 \rightarrow \mathrm{n}=3.7 \mathrm{kmol} \times 2 / 3 \\
& \mathrm{n}=2.5 \mathrm{kmol}
\end{aligned}
$$

We now know that 7.5 kg of hydrogen will produce 2.5 kmol of ammonia.
Use the IDEAL GAS LAW to calculate the volume of ammonia.

$$
\begin{aligned}
& V=\frac{n R T}{P} \\
& V=(2.5 \mathrm{kmol})(8.31 \mathrm{kPa}-\mathrm{L} / \mathrm{K} \mathrm{~mol})(80+273) \mathrm{K} / 450 \mathrm{kPa} \\
& V=16 \mathrm{~kL}
\end{aligned}
$$

Try Thise Hydrogen gas is produced when sodium metal is added to water. What mass of sodium is necessary to produce 20.0 L of gas at SATP?

$$
\begin{array}{llll}
2 \mathrm{Na}(\mathrm{~s})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \quad \rightarrow \quad 2 \mathrm{NaOH}(\mathrm{aq}) \quad+\quad 1 \mathrm{H}_{2}(\mathrm{~g}) \\
\mathrm{m}=? & & & 20.0 \mathrm{~L} @ \text { SATP }
\end{array}
$$

Calculate the number of moles of hydrogen.

Calculate the number of moles of sodium required using the molar ratio from the balanced chemical equation. Notice that there are twice as many moles of sodium as there are of hydrogen in the equation.

Use the formula $\mathbf{m}=\mathbf{n x} \mathbf{M}$ to calculate the mass of sodium.

## Gas Stoichiometry

Complete the following stoichiometric problems. Communicate your problem-solving approach, using internationally accepted symbols for elements, quantities, numbers, and units.

1. The first step in the industrial manufacture of sulfuric acid is the complete combustion of octasulfur. What mass of octasulfur is required to produce 112 L of sulfur dioxide at STP?
2. Coal can undergo an incomplete combustion in the absence of a plentiful supply of air to produce deadly carbon monoxide gas. What volume of carbon monoxide is produced at SATP by the incomplete combustion of $150 . \mathrm{kg}$ of coal?
3. The first recorded observation of hydrogen gas was made by the famous alchemist Paracelsus when he added iron to sulfuric acid. Calculate the volume of hydrogen gas at $20^{\circ} \mathrm{C}$ and 98 kPa produced by adding $10 . \mathrm{g}$ of iron to an excess of sulfuric acid.
4. Ammonia reacts with sulfuric acid to form the important fertilizer, ammonium sulfate. What mass of ammonium sulfate can be produced from 75 kL of ammonia at $10^{\circ} \mathrm{C}$ and $110 . \mathrm{kPa}$ ?
