Gas Stoichiometry

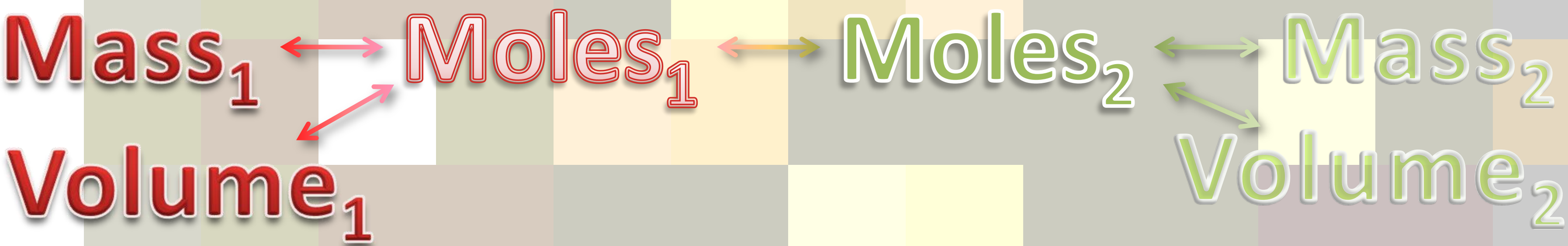
The New Road Map

- When any of the reagents in a reaction is a gas, a relationship exists between the volume and the number of moles defined by the ideal gas law.
- You may recall the roadmap for mass problems.

- Now volume can be added to the mix using the ideal gas law.

Moles and the Gas Law

- The ideal gas law is PV = *n*RT.
- Solving for moles, we get $n = \frac{PV}{RT}$.
- Once you have moles, you can solve for any of the quantities in the roadmap by factor label.



- Additionally, you can start with the roadmap to find moles, and substitute into the gas law to find any of the other variables.

Volume-Mass Problems

How many grams of rust (Fe_2O_3) form when iron reacts with 25.0 L of oxygen at 25°C and 200. kPa?

- **Step 1:** Write a balanced equation

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

- **Step 2:** Substitute values into the gas equation to get the number of moles of gas.

$$n = \frac{PV}{RT} = \frac{(200.kPa)(1atm)(25.0L)}{(101.3kPa)\left(0.0821\frac{L \bullet atm}{mol \bullet K}\right)(298K)} = 2.02mol$$

- **Step 3:** Solve the remaining problem by the factor label method.

$$\left(2.02mol_{O_2}\right)\left(\frac{2mol_{Fe_2O_3}}{3mol_{O_2}}\right)\left(\frac{159.7g_{Fe_2O_3}}{1mol_{Fe_2O_3}}\right) = 215g_{Fe_2O_3}$$

Volume-Volume Problems

- At constant temperature and pressure, volume-volume problems can be handled simply by using Avogadro's law ($V \propto n$) because all the other variables in the gas laws cancel out.

How many milliliters of ammonia are formed when 150.mL of hydrogen combines with nitrogen at constant temperature and pressure?

- **Step 1:** Write a balanced equation.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

- **Step 2:** Set up a proportion and solve.

$$\frac{3\text{ mol}}{150.\text{mL}} = \frac{2\text{ mol}}{x} \qquad x = 100.\text{ mL}$$

STP Problems

- At STP the molar volume (GMV) of a gas is always 22.4 *L*. Since 22.4 *L* = 1 *mol* at STP, the GMV can be used in a factor label problem in much the same way as the molar mass (GFM).

How many liters of oxygen are liberated when 18.4 g of potassium chlorate decompose at STP?

- **Step 1:** Write a balanced equation.

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

- **Step 2:** Solve by the factor label method.

$$\left(18.4 g_{KClO_3}\right)\left(\frac{1 mol_{KClO_3}}{122.5 g_{KClO_3}}\right)\left(\frac{3 mol_{O_2}}{2 mol_{KClO_3}}\right)\left(\frac{22.4 L}{1 mol}\right) = 5.05 L_{O_2}$$