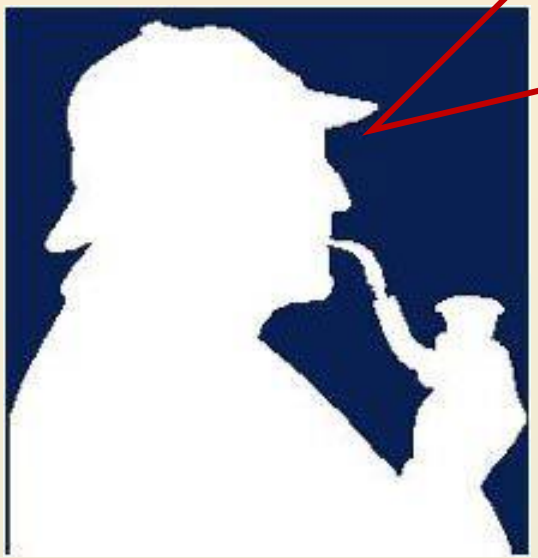
Stoichiometry



"In solving a problem of this sort, the grand thing is to be able to reason backward. This is a very useful accomplishment, and a very easy one, but people do not practice it much."

Sherlock Holmes, in Sir Arthur Conan Doyle's A Study in Scarlet

Stoichiometry - The study of quantities of materials consumed and produced in chemical reactions.

Calculating Masses of Reactants and Products

1. Balance the equation.
2. Convert mass or volume to moles, if necessary.
3. Set up mole ratios.
4. Use mole ratios to calculate moles of desired substituent.
5. Convert moles to mass or volume, if necessary.

Working a Stoichiometry Problem

6.50 grams of aluminum reacts with an excess of oxygen. How many grams of aluminum oxide are formed.

1. Identify reactants and products and write the balanced equation.

$$4\ Al + 3\ O_2 \longrightarrow 2\ Al_2O_3$$

a. Every reaction needs a yield sign!

b. What are the reactants?

c. What are the products?

d. What are the balanced coefficients?

Working a Stoichiometry Problem

6.50 grams of aluminum reacts with an excess of oxygen. How many grams of aluminum oxide are formed?

$$4\ Al + 3\ O_2 \rightarrow 2Al_2O_3$$

$$6.50 \times 2 \times 101.96 \div 26.98 \div 4 = 12.3\ g\ Al_2O_3$$

$$\frac{6.50\ \cancel{g\ Al} \quad 1\ \cancel{mol\ Al} \quad 2\ \cancel{mol\ Al_2O_3} \quad 101.96\ g\ Al_2O_3}{\quad 26.98\ \cancel{g\ Al} \quad 4\ \cancel{mol\ Al} \quad 1\ \cancel{mol\ Al_2O_3}} = ?\ g\ Al_2O_3$$

Gas Stoichiometry #1

If reactants and products are at the same conditions of temperature and pressure, then mole ratios of *gases* are also volume ratios.

$$3\ H_2(g) + N_2(g) \rightarrow 2NH_3(g)$$

3 moles H_2 + 1 mole N_2 → 2 moles NH_3

3 liters H_2 + 1 liter N_2 → 2 liters NH_3

Gas Stoichiometry #2

How many liters of ammonia can be produced when 12 liters of hydrogen react with an excess of nitrogen?

$$\underline{3}\ H_2(g) + N_2(g) \rightarrow \underline{2}NH_3(g)$$

$$\frac{12\ \cancel{L\ H_2}}{} \left| \frac{2\ L\ NH_3}{3\ \cancel{L\ H_2}} \right. = 8.0\ L\ NH_3$$

Gas Stoichiometry #3

How many liters of oxygen gas, at STP, can be collected from the complete decomposition of 50.0 grams of potassium chlorate?

$$2\ KClO_3(s) \rightarrow 2\ KCl(s) + 3\ O_2(g)$$

50.0 g $KClO_3$	1 mol $KClO_3$	3 mol O_2	22.4 L O_2
	122.55 g $KClO_3$	2 mol $KClO_3$	1 mol O_2

= 13.7 L O_2

Gas Stoichiometry #4

How many liters of oxygen gas, at 37.0°C and 0.930 atmospheres, can be collected from the complete decomposition of 50.0 grams of potassium chlorate?

$$2\ KClO_3(s) \rightarrow 2\ KCl(s) + 3\ O_2(g)$$

$$\frac{50.0\ \cancel{g\ KClO_3}}{} \left| \frac{1\ \cancel{mol\ KClO_3}}{122.55\ \cancel{g\ KClO_3}} \right| \frac{3\ mol\ O_2}{2\ \cancel{mol\ KClO_3}} = 0.612\ mol\ O_2$$

$$V = \frac{nRT}{P} = \frac{(0.612\ mol)(0.082\ 1\ \frac{L \cdot atm}{mol \cdot K})(310\ K)}{0.930\ atm} = 16.7\ L$$