NOTES: 12.1-12.2 – Mole Ratios (Using Balanced Equations)

Balanced Equations…

- a balanced chemical equation is like a recipe that tells a chemist:

  -what **quantities** of **reactants** to mix; and

  -what **quantities** of **products** to expect

Balanced Equations…

- the **quantity** of a reactant or product is usually measured in **grams** or **moles**;

- however, it could be measured in **liters** (gases), tons, **individual molecules**, etc.

<u>STOICHIOMETRY:</u>

- **STOICHIOMETRY** = <u>**the calculation of quantities in chemical equations**</u>

- for chemists, it is a form of bookkeeping

<u>“everyday” example:</u>

- a cookie recipe calls for (among other ingredients):

  -1.25 cups butter

  -1 cup sugar

  -2 eggs

  -1 cup brown sugar

  -2.5 cups flour

“everyday” example:

- according to the recipe, this will make 48 cookies…so, we could summarize this:

1.25 cups butter
1 cup sugar
2 eggs
1 cup brown sugar
2.5 cups flour

48 cookies

example:

- all of these amounts may be used as ratios, or conversion factors, in calculations

- if you wanted to make 96 cookies, how many cups of flour would you need?

$$\frac{96\,\text{cookies}}{} \times \frac{2.5\,\text{cups flour}}{48\,\text{cookies}} =$$

<u>example:</u>

- all of these amounts may be used as ratios, or conversion factors, in calculations

- if you wanted to make 96 cookies, how many cups of flour would you need?

$$\frac{96\ \text{cookies}}{} \times \frac{2.5\ \text{cups flour}}{48\ \text{cookies}} =$$

<u>5.0 cups flour</u>

- assuming you had excess amounts of all ingredients, what is the maximum number of cookies you could make with 3.50 cups of butter?

$$\frac{3.50\ \text{cups butter}}{} \times \frac{48\ \text{cookies}}{1.25\ \text{cups butter}} =$$

- assuming you had excess amounts of all ingredients, what is the maximum number of cookies you could make with 3.50 cups of butter?

$$\frac{3.50\ \text{cups butter}}{} \times \frac{48\ \text{cookies}}{1.25\ \text{cups butter}} =$$

<u>134.4 cookies</u>

(= 134 cookies)

Balanced Chemical Equations

- we can make similar interpretations (and calculations) using a balanced chemical equation

- consider the production of ammonia from nitrogen and hydrogen:

$$\underline{N_2 \quad + \quad 3H_2 \quad \rightarrow \quad 2NH_3}$$

We can interpret this equation in terms of:

$$\mathbf{N_2 + 3H_2 \rightarrow 2NH_3}$$

- **particles**:
  1 molecule of N_2 reacts with
  3 molecules of H_2 to produce
  2 molecules of NH_3

  (a **1:3:2 ratio**)

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

Example: How many H_2 molecules are required to react with 15 molecules of N_2?

$$\frac{15\,\text{molecules } N_2}{} \times \frac{3\,\text{molecules } H_2}{1\,\text{molecule } N_2} =$$

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

<u>Example</u>: How many H_2 molecules are required to react with 15 molecules of N_2?

$$\frac{15\ \text{molecules}\ N_2}{} \times \frac{3\ \text{molecules}\ H_2}{1\ \text{molecule}\ N_2} =$$

<u>45 molecules H_2</u>

We can also interpret this equation in terms of:

$$\mathbf{N_2 + 3H_2 \rightarrow 2NH_3}$$

- **MOLES**:

  1 mole of N_2 reacts with

  3 moles of H_2 to produce

  2 moles of NH_3

  (a **1:3:2 ratio**)

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

Example: How many moles of NH_3 will be produced when 37.0 moles of H_2 react? (assume there is enough N_2 to react)

$$\frac{37.0\ \text{moles } H_2}{} \times \frac{2\ \text{moles } NH_3}{3\ \text{moles } H_2} =$$

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

Example: How many moles of NH_3 will be produced when 37.0 moles of H_2 react? (assume there is enough N_2 to react)

$$\frac{37.0 \text{ moles } H_2}{} \times \frac{2 \text{ moles } NH_3}{3 \text{ moles } H_2} = \underline{24.7 \text{ moles } NH_3}$$

examples for you to try!

Iron (III) oxide reacts with carbon monoxide to form iron and carbon dioxide.

$$\underline{Fe_2O_3 \quad + \quad 3\,CO \rightarrow 2\,Fe \quad + \quad 3\,CO_2}$$

How many CO molecules are required to react with 25 particles of Fe_2O_3?

$$\frac{25\ \text{form. units}\ Fe_2O_3}{} \times \frac{3\ \text{molecules}\ CO}{1\ \text{form. unit}\ Fe_2O_3} =$$

Iron (III) oxide reacts with carbon monoxide to form iron and carbon dioxide.

$$\underline{\mathbf{Fe_2O_3} \quad + \quad 3\,\mathbf{CO} \rightarrow 2\,\mathbf{Fe} \quad + \quad 3\,\mathbf{CO_2}}$$

How many CO molecules are required to react with 25 particles of Fe_2O_3?

$$\frac{25\text{ form. units }Fe_2O_3}{} \times \frac{3\text{ molecules CO}}{1\text{ form. unit }Fe_2O_3} =$$

75 molecules CO

Iron (III) Oxide reacts with carbon monoxide to form iron and carbon dioxide.

$$\underline{Fe_2O_3 \quad + \quad 3\,CO \rightarrow 2\,Fe \quad + \quad 3\,CO_2}$$

How many iron atoms can be produced by the reaction of 2.5 x 10^5 particles of Fe_2O_3?

$$\frac{2.5\times10^{5}\,\text{form. units } Fe_2O_3}{} \times \frac{2\text{ atoms Fe}}{1\text{ form. unit } Fe_2O_3} =$$

Iron (III) Oxide reacts with carbon monoxide to form iron and carbon dioxide.

Fe_2O_3 + 3 CO → 2 Fe + 3 CO_2

How many iron atoms can be produced by the reaction of 2.5 x 10^5 particles of Fe_2O_3?

$$\frac{2.5\times10^{5}\,\text{form. units } Fe_2O_3}{} \times \frac{2\text{ atoms Fe}}{1\text{ form. unit } Fe_2O_3} =$$

5.0 x 10^5 atoms Fe

- consider the following reaction:

$$\mathbf{2H_2S \quad + \quad 3O_2 \quad \rightarrow \quad 2SO_2 + \quad 2H_2O}$$

How many moles of O_2 are required to react with 22.5 moles of H_2S?

$$\frac{22.5\ \text{moles}\ H_2S}{} \times \frac{3\text{moles}\ O_2}{2\ \text{moles}\ H_2S} =$$

- consider the following reaction:

$$2H_2S \quad + \quad 3O_2 \quad \rightarrow \quad 2SO_2 + \quad 2H_2O$$

How many moles of O_2 are required to react with 22.5 moles of H_2S?

$$\frac{22.5\text{ moles } H_2S}{} \times \frac{3\text{moles } O_2}{2\text{ moles } H_2S} =$$

<u>**33.8 moles O_2**</u>