Unit 8 Stoichiometry
Limiting Reactant, Excess Reactant, Theoretical Yield, and Percent Yield

Name ___________________
Block # ____

Part A: Limiting Reactant

1. Butane, C_4H_{10}, burns in the presence of oxygen to form carbon dioxide and water. Determine the limiting reactant if the reaction begins with 25.0 grams of each reactant.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

Note: It doesn't matter which product you solve for, as long as you solve for the same product each time.

Molar Mass of C_4H_{10}
C: 4 x 12 = 48
H: 10 x 1 = 10
Total Mass = **58 g**

REACTANT #1

$$\frac{25.0 \text{ grams } C_4H_{10}}{1} \left| \frac{1 \text{ mole } C_4H_{10}}{58 \text{ grams } C_4H_{10}} \right| \frac{8 \text{ moles } CO_2}{2 \text{ mole } C_4H_{10}} \left| \frac{44 \text{ grams } CO_2}{1 \text{ mole } CO_2} \right| = 75.9 \text{ grams } CO_2$$

Molar Mass of CO_2
C: 1 x 12 = 12
O: 2 x16 = 32
Total Mass = **44 g**

REACTANT #2

Molar Mass of O_2
O: 2 x 16 =
Total Mass = **32 g**

$$\frac{25.0 \text{ grams } O_2}{1} \left| \frac{1 \text{ mole } O_2}{32 \text{ grams } O_2} \right| \frac{8 \text{ moles } CO_2}{13 \text{ mole } O_2} \left| \frac{44 \text{ grams } CO_2}{1 \text{ mole } CO_2} \right| = 21.2 \text{ grams } CO_2$$

Because it makes less carbon dioxide, <u>Reactant #2 (O_2) is the limiting reactant</u>.

2. Iron ore is corroded by oxygen to form iron III oxide, the reddish brown color of rust. Determine the limiting reactant if the reaction begins with 10.0 moles of each reactant.

$$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$$

Note: If the reactant is given in MOLES, then you don't need to convert from grams with molar mass.

DO NOT USE MASS:
If it starts with moles, you don't need the molar mass in grams.

REACTANT #1

$$\frac{10.0 \text{ moles Fe}}{1} \left| \frac{2 \text{ moles } Fe_2O_3}{4 \text{ mole Fe}} \right| \frac{159.6 \text{ grams } Fe_2O_3}{1 \text{ mole } Fe_2O_3} \right| = 798 \text{ grams } Fe_2O_3$$

Molar Mass of Fe_2O_3
Fe: 2 x 55.8 = 111.6
O: 3 x16 = 48.0
Total Mass = **159.6 g**

REACTANT #2

DO NOT USE MASS:
If it starts with moles, you don't need the molar mass in grams.

$$\frac{10.0 \text{ moles } O_2}{1} \left| \frac{2 \text{ moles } Fe_2O_3}{3 \text{ mole } O_2} \right| \frac{159.6 \text{ grams } Fe_2O_3}{1 \text{ mole } Fe_2O_3} \right| = 1064 \text{ grams } Fe_2O_3$$

Because it makes less iron III oxide, <u>Reactant #1 (Fe) is the limiting reactant</u>.

3. Magnesium burns in the presence of oxygen to form magnesium oxide. Determine the limiting reactant, when a chemist ignites 1.00 gram of magnesium in a flask containing 0.500 liters of oxygen at STP.

$$2\ Mg_{(s)} + 1\ O_{2\,(g)} \rightarrow 2\ MgO_{(s)}$$

Note: Because one reactant is measured in grams and the other is measured in liters, the equations will each use different conversion factors. However, the goal is still to solve each equation for grams of product.

Molar Mass of Mg

24.305
Mg
12
Magnesium

REACTANT #1

$$\frac{1.00\ \text{gram Mg}}{1}\left|\frac{1\ \text{mole Mg}}{24.3\ \text{grams Mg}}\right|\frac{2\ \text{moles MgO}}{2\ \text{mole Mg}}\left|\frac{40.3\ \text{grams MgO}}{1\ \text{mole MgO}}\right| = 1.66\ \text{grams MgO}$$

Molar Mass of MgO
Mg: 1x 24.3=24.3
O: 1 x 16 = 16
Total Mass = **40.3 g**

REACTANT #2

DO NOT USE GRAMS
The word problem said liters so use **22.4 Liters** per mole at STP

$$\frac{0.500\ \text{liters}\ O_2}{1}\left|\frac{1\ \text{mole}\ O_2}{22.4\ \text{liters}\ O_2}\right|\frac{2\ \text{moles MgO}}{1\ \text{mole}\ O_2}\left|\frac{40.3\ \text{grams MgO}}{1\ \text{mole MgO}}\right| = 1.80\ \text{grams MgO}$$

Because it makes less magnesium oxide, <u>Reactant #1 (Mg) is the limiting reactant</u>.

Part B: Excess Reactant

1. Based on the limiting reactant from **Part A #1**, determine the amount of excess reactant leftover. Butane, C_4H_{10}, burns in the presence of oxygen to form carbon dioxide and water.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

Note: Start with limiting reactant (Reactant #2) to solve for the amount of excess reactant used.

REACTANT #2: Limiting Reactant — REACTANT #1: Excess Reactant

$$\frac{25.0\ \text{grams}\ O_2\ \text{used}}{1}\left|\frac{1\ \text{mole}\ O_2}{32\ \text{grams}\ O_2}\right|\frac{2\ \text{moles}\ C_4H_{10}}{13\ \text{mole}\ O_2}\left|\frac{58\ \text{grams}\ C_4H_{10}}{1\ \text{mole}\ C_4H_{10}}\right| = 6.97\ \text{grams}\ C_4H_{10}\ \text{used}$$

Now subtract the amount of excess used from the original amount.

$$25.0\ \text{grams}\ C_4H_{10} - 6.97\ \text{grams}\ C_4H_{10}\ \text{used} = \boxed{18.0\ \text{grams}\ C_4H_{10}\ \text{leftover}}$$

2. Based on the limiting reactant from **Part A #2**, determine the amount of excess reactant leftover. Iron ore is corroded by oxygen to form iron III oxide, the reddish brown color of rust.

$$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$$

Note: Start with limiting reactant (Reactant #1) to solve for the amount of excess reactant used. If the word problem is done in MOLES, it is okay to keep everything in MOLES.

REACTANT #1: Limiting Reactant — REACTANT #2: Excess Reactant

$$\frac{10.0\ \text{moles Fe used}}{1}\left|\frac{3\ moles\ O_2}{4\ moles\ Fe}\right| = \ 7.5\ \text{moles}\ O_2\ \text{used}$$

Now subtract the amount of excess used from the original amount.

$$10.0\ \text{moles}\ O_2 - 7.5\ \text{moles}\ O_2\ \text{used} = \boxed{2.5\ \text{moles}\ O_2\ \text{leftover}}$$

3. Based on the limiting reactant from **Part A #3**, determine the amount of excess reactant leftover. Magnesium burns in the presence of oxygen to form magnesium oxide.

$$2\ Mg + 1\ O_2 \rightarrow 2\ MgO$$

Note: Start with limiting reactant (Reactant #1) to solve for the amount of excess reactant used. Since the excess reactant is originally given in LITERS, covert the amount used into LITERS.

REACTANT #1: Limiting Reactant — REACTANT #2: Excess Reactant

$$\frac{1.00\ \text{gram Mg}}{1}\left|\frac{1\ \text{mole Mg}}{24.3\ \text{grams Mg}}\right|\frac{1\ moles\ O_2}{2\ \text{mole Mg}}\left|\frac{22.4\ \text{liters}\ O_2}{1\ \text{mole}\ O_2}\right| = 0.461\ \text{liters}\ O_2\ \text{used}$$

Now subtract the amount of excess used from the original amount.

$$0.500\ \text{liters}\ O_2 - 0.461\ \text{liters}\ O_2\ \text{used} = \boxed{0.039\ \text{liters}\ O_2\ \text{leftover}}$$

Part C: Percent Yield

$$\%\ \text{Yield} = \frac{\text{Amount of Product from Word Problem}}{\text{Amount of Product based on Limiting Reactant}} \times 100$$

4. Based on the limiting reactant from **Part A #1**, determine the percent yield for the reaction, if a chemist is only able to produce 17.32 grams of carbon dioxide in the lab.

$$\%\ \text{Yield} = \frac{17.32\ \text{gram}\ CO_2}{21.2\ \text{grams}\ CO_2} \times 100 = \boxed{81.70\%\ \text{Yield}}$$

5. Based on the limiting reactant from **Part A #2**, determine the percent yield for the reaction, if a chemist is only able to produce 689.21 grams of iron III oxide in the lab.

$$\% \text{ Yield} = \frac{\mathbf{689.21\ gram\ Fe_2O_3}}{\mathbf{798\ grams\ Fe_2O_3}} \times 100 = \boxed{\mathbf{86.367\%\ Yield}}$$

6. Based on the limiting reactant from **Part A #3**, determine the percent yield for the reaction, if a chemist is only able to produce 1.35 grams of magnesium oxide in the lab.

$$\% \text{ Yield} = \frac{\mathbf{1.35\ gram\ MgO}}{\mathbf{1.66\ grams\ MgO}} \times 100 = \boxed{\mathbf{81.3\%\ Yield}}$$