LIMITING REACTANTS

CONSIDER THE FOLLOWING REACTIONS

- $BaCl_2 + MgSO_4 \rightarrow BaSO_4 + MgCl_2$
- 2KI + Pb(NO3)2 → PbI2 + 2KNO3
- Fe + H20 (g) → Fe2O3 + H2

All reactions have two reactants yielding the reaction.

WHAT IS A LIMITING REACTANT?

The reactant that limits the production of the reaction.

WHAT ABOUT THE OTHER REACTANT?

The excess reactant is the one that is not limited and has substance remaining after the reaction.

IF YOU START WITH MOLES OF A REACTANT.

1. Convert given mass to moles of the given.
2. Identify the mole ratio within the reaction of reactants to product.
3. Convert the moles of the given to moles of the product
4. Repeat this process for the other value of the given reactant.
5. Convert to the same product as before.
6. Value that converts into a lesser mole value for the product is the limiting reactant.

DETERMINING MOLE RATIO

For example:

$$2KI + Pb(NO3)_2 \rightarrow PbI_2 + 2KNO_3$$

The mole ratios:

- 2 KI to 1 PbI_2
- 2 KI to 2 KNO_3
- $Pb(NO_3)_2$ to PbI_2
- $Pb(NO_3)_2$ to $2KNO_3$

LIMITING REACTANT - PRACTICE

The black oxide of iron, Fe_3O_4, occurs in nature as the mineral magnetite. This substance can also be made in the laboratory by the reaction between red-hot iron and steam.

$$3Fe + 4H_20 \rightarrow Fe_3O_4 + 4H_2$$

When 36.0g of $H_2O$is mixed with 67.0g Fe, which is the limiting reactant?

SOLVE:

Step 1: Convert given mass to moles of the given. (Use molar mass of each compound)

- 36.0g of H_2O * $(\frac{1mol}{18.02g})$ = 2 mol H_2O
- 67.0g Fe * $(\frac{1mol}{55.85g})$ = 1.2 mol Fe

Step 2: Identify the mole ratio within the reaction of reactants to product.

$$4Fe + 3H_2O \rightarrow 2Fe_2O_3 + 3H_2$$

- $3H_2O : 2Fe_2O_3$ (3:2)
- $4Fe : 2Fe_2O_3$ (4:2 = 2:1)

SOLVE:

Step 3: Convert the moles of the given to moles of the product. (Use mole ratios)

- 2 mol H_2O * $(\frac{2\ mol\ Fe2O3}{3\ mol\ H2O})$ = 1.33 mol Fe_2O_3

Step 5 and 6: Repeat this process for the other value of the given reactant.

- 1.2 mol Fe * $(\frac{1\ mol\ Fe2O3}{2\ mol\ Fe})$ = 0.6 mol Fe_2O_3

Step 6: Value that converts into a lesser mole value for the product is the limiting reactant.

- Fe is the limiting reactant producing 0.6 mol Fe_2O_3

DETERMINE MASS OF PRODUCT

A remaining reactant has material left after the reaction is completed.

To determine mass:

1. Determine moles of product produced by limiting reactant
2. Convert moles of product to mass of the product using molar mass.

LIMITING REACTANT - PRACTICE

Considering the reaction of the black iron oxide, Fe_3O_4,

$$3Fe + 4H_20 \rightarrow Fe_3O_4 + 4H_2$$

What mass in grams of black iron oxide is produced?

LIMITING REACTANT - PRACTICE

Step 1: Determine moles of product produced by limiting reactant. (For this example, moles of product was found in last problem)

- 0.6 mol Fe_2O_3

Step 2: Convert moles of product to mass of the product using molar mass.

- 0.6 mol $Fe_2O_3 * (\frac{111.7\ g}{1\ mol}) = 67.02$ g Fe_2O_3

REMAINING MASS OF EXCESS REACTANT

A remaining reactant has material left after the reaction is completed.

To determine mass:

1. Determine moles of product produced by limiting reactant
2. Use moles ratio to determine the amount of moles for the excess reactant.
3. Use the molar mass of the excess reactant to convert moles to mass.
4. Find the difference between the given amount of reactant and the amount used in the reaction.

LIMITING REACTANT - PRACTICE

Considering the reaction of the black iron oxide, Fe_3O_4,

$$3Fe + 4H_20 \rightarrow Fe_3O_4 + 4H_2$$

What mass in grams of excess reactant remains when the reaction is produced?

LIMITING REACTANT - PRACTICE

Step 1: Determine moles of product produced by limiting reactant.

(For this problem the moles of product was found in the first problem)

- 0.6 mol Fe_2O_3

Step 2: Use moles ratio to determine the amount of moles for the excess reactant.

- 0.6 mol Fe_2O_3 * $(\frac{3\ mol\ H2O}{2\ mol\ Fe2O3})$ = 0.9 mol H_2O

Step 3: Use the molar mass of the excess reactant to convert moles to mass.

- 0.9 mol H_2O * $(\frac{18.02g}{1mol})$ = 16.22 g H_2O

Step 4: Find the difference between the given amount of reactant and the amount used in the reaction.

- 36 g - 16.22 g = 19.78 g H_2O

PERCENTAGE YIELD

- In real life it is a common saying that “things did not go as planned”
- Reactions are the same.
- The chemical reactions that we write are considered **theoretical** (ideal) **yield.**
  - Theoretical Yield: the maximum amount of product that can be produced from a given amount of reactant.
- In a lab, the material that is produced is considered the **actual yield**.
  - Actual Yield: measured amount of a product obtained from a reaction.

PERCENTAGE YIELD

- Percentage yield is the percentage of the ratio between the actual yield to the theoretical yield.

$$\frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

PERCENTAGE YIELD - PRACTICE

Chlorobenzene, C_6H_5Cl, is used in the production of asprin, dyes, and disinfectants. One industrial method of preparing chlorobenzene is to react benzene, C_6H_6 with chlorine.

$$C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl$$

When 36.8g of C_6H_6 react with an excess of Cl_2, the actual yield of C_6H_5Cl is 38.8g.

What is the percentage yield of C_6H_5Cl ?

To solve this problem identify the mass produced by the limiting reactant C_6H_6 as done before)