Name: Key
Blk: ____ Date: ____

Chemistry 11
STOICHIOMETRY
OF EXCESS + LIMITING REACTANTS

Until now all of the stoich problems we have completed assumed that all of the reactants are used up in the reaction. HOWEVER, sometimes chemical reactions are carried out so as to:

1. To ensure that all of another substance (toxic etc) is used up.
2. unavailability - you only have a specific amount in stock.

IMPORTANT TERMINOLOGY:

Excess Reactant: the substance that you have more than enough of

Limiting Reactant: the substance that determines the amount of products that will form because you have a limited amount of it.

Example 1. If for the synthesis reaction between hydrogen gas and oxygen gas, 20.0 g of H_2 (g) reacts with 100.0 g of O_2 (g), which reactant is in excess and by how much?

Step 1. Write out the balanced equation:

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

Step 2. Use both masses to solve for the mass of the **same** product

$$20.0\,g\ H_2 \times \frac{1\,mol\ H_2}{2.0\,g\ H_2} \times \frac{2\,mol\ H_2O}{2\,mol\ H_2} \times \frac{18.0\,g\ H_2O}{1\,mol\ H_2O} = 180\,g\ H_2O$$

$$100.0\,g\ O_2 \times \frac{1\,mol\ O_2}{32.0\,g\ O_2} \times \frac{2\,mol\ H_2O}{1\,mol\ O_2} \times \frac{18.0\,g\ H_2O}{1\,mol\ H_2O} = 112.5\,g\ H_2O$$

Step 3. The substance that produces the least amount of product is the LIMITING REACTANT

$\therefore$ 100.0 g O_2 is LIMITING

Step 4. To determine the amount of EXCESS REACTANT use the mass of the limiting reactant to solve for the actual mass of excess used:

$$100.0\,g\ O_2 \times \frac{1\,mol\ O_2}{32.0\,g\ O_2} \times \frac{2\,mol\ H_2}{1\,mol\ O_2} \times \frac{2.0\,g\ H_2}{1\,mol\ H_2} = 12.5\,g\ H_2$$

$\therefore$ 13 g H_2

Step 5. Subtract the above value from the amount of excess you have.

$\therefore$ 20.0 g - 13 g = **7 g H_2 remains**

Example 2. If 56.8 grams of $FeCl_2$, 14.0 g of KNO_3 and 40.0 g of HCl are mixed and allowed to react according to the equation:

$$3\ FeCl_2 + KNO_3 + 4\ HCl \rightarrow 3\ FeCl_3 + NO + 2\ H_2O + KCl$$

Which reactants are in excess and by how much?

Step 1. Write out the balanced equation:

$$3\ FeCl_2 + KNO_3 + 4HCl \longrightarrow 3FeCl_3 + NO + 2H_2O + KCl$$

Step 2. Use all masses to solve for the mass of the **same** product ⇒ NO = 30.0 g // H_2O ⇒ 18.0 g.

$$56.8\text{ g } FeCl_2 \times \frac{1\text{ mol } FeCl_2}{126.8\text{ g}} \times \frac{1\text{ mol NO}}{3\text{ mol } FeCl_2} \times \frac{30.0\text{ g NO}}{1\text{ mol NO}} = 4.48\text{ g NO} \;//\; 5.38\text{ g } H_2O$$

$$14.0\text{ g } KNO_3 \times \frac{1\text{ mol } KNO_3}{101.1\text{ g}} \times \frac{1\text{ mol NO}}{1\text{ mol } KNO_3} \times \frac{30.0\text{ g NO}}{1\text{ mol NO}} = 4.16\text{ g NO} \;//\; 4.99\text{ g } H_2O$$

$$40.0\text{ g HCl} \times \frac{1\text{ mol HCl}}{36.5\text{ g HCl}} \times \frac{1\text{ mol NO}}{4\text{ mol HCl}} \times \frac{30.0\text{ g NO}}{1\text{ mol NO}} = 8.22\text{ g NO} \;//\; 9.86\text{ g } H_2O$$

Step 3. The substance that produces the least amount of product is the LIMITING REACTANT

∴ 14.0 g of KNO_3 is the LIMITING REACTANT.

Step 4. To determine the amount of EXCESS REACTANTS use the mass of the limiting reactant to solve for the actual mass of the excess used:

$$14.0\text{ g } KNO_3 \times \frac{1\text{ mol } KNO_3}{101.1\text{ g } KNO_3} \times \frac{3\text{ mol } FeCl_2}{1\text{ mol } KNO_3} \times \frac{126.8\text{ g } FeCl_2}{1\text{ mol } FeCl_2} = 52.7\text{ g } FeCl_2$$

$$14.0\text{ g } KNO_3 \times \frac{1\text{ mol } KNO_3}{101.1\text{ g } KNO_3} \times \frac{4\text{ mol HCl}}{1\text{ mol } KNO_3} \times \frac{36.5\text{ g HCl}}{1\text{ mol HCl}} = 20.2\text{ g HCl}$$

Step 5. Subtract the above values from the amount of excesses that you have.

∴ 56.8 g $FeCl_2$ − 52.7 g = **4.1 g $FeCl_2$ in excess**

40.0 g HCl − 20.2 g HCl = **19.8 g HCl in excess**