Analogy: Today I want to make chocolate chip cookies. If I follow the recipe it calls for 3 cups flour and 2 cups of chips. To make 2 dozen cookies

Name:_____
Blk:_____ Date:_____

In my pantry I have 30 cups of flour & exactly 2 cups of chocolate chips

∴ I will make 2 dozen cookies, use all chocolate chips + have 27 cups of flour left over

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:

1. Purposely: to ensure that a toxic reactant is all consumed.

2. unavoidably: you only have a specific amount of the reactant in stock.

IMPORTANT TERMINOLOGY:

Excess Reactant(s): The substance(s) that you will have left over (unreacted) (flour)

Limiting Reactant: The substance that will be all used up; it determines the amount of product(s) that are formed (Choc. chips)

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? What mass of water is made?

Step 1. Write out the balanced equation:

$$2\,H_2(g) + 1\,O_2(g) \longrightarrow 2\,H_2O(g)$$

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

$$20.0\text{ g } H_2\left(\frac{1\text{ mol } H_2}{2.0\text{ g } H_2}\right)\left(\frac{2\text{ mol } H_2O}{2\text{ mol } H_2}\right)\left(\frac{18.0\text{ g } H_2O}{1\text{ mol } H_2O}\right) = 180\text{ g } H_2O$$

$$100.0\text{ g } O_2\left(\frac{1\text{ mol } O_2}{32.0\text{ g } O_2}\right)\left(\frac{2\text{ mol } H_2O}{1\text{ mol } O_2}\right)\left(\frac{18.0\text{ g } H_2O}{1\text{ mol } H_2O}\right) = \boxed{113\text{ g } H_2O} \leftarrow$$

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

100.0 g O_2 is the Limiting reactant

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:

$$100.0\text{ g } O_2\left(\frac{1\text{ mol } O_2}{32.0\text{ g } O_2}\right)\left(\frac{2\text{ mol } H_2}{1\text{ mol } O_2}\right)\left(\frac{2.0\text{ g } H_2}{1\text{ mol } H_2}\right) = 12.5\text{ g } H_2$$

(O_2: L.R.; H_2: E.R used; ~13 g H_2)

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

$$20.0\text{ g } H_2 - 13\text{ g } H_2 = \boxed{7\text{ g } H_2 \text{ left over}}$$

(have) (use)

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:

$1N = 14.0\ g$
$1O = 16.0\ g$
$30.0\ g\ NO$

$3FeCl_2 + 1KNO_3 + 4HCl \rightarrow 3FeCl_3 + 1NO + 2H_2O + KCl$

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

$56.8\ g\ FeCl_2 \left(\frac{1\ mol\ FeCl_2}{126.8\ g}\right)\left(\frac{1\ mol\ NO}{3\ mol\ FeCl_2}\right)\left(\frac{30.0\ g}{1\ mol\ NO}\right) = 4.48\ g\ NO$

$14.0\ g\ KNO_3 \left(\frac{1\ mol\ KNO_3}{101.1\ g}\right)\left(\frac{1\ mol\ NO}{1\ mol\ KNO_3}\right)\left(\frac{30.0\ g}{1\ mol\ NO}\right) = 4.16\ g\ NO$

$40.0\ g\ HCl \left(\frac{1\ mol\ HCl}{36.5\ g}\right)\left(\frac{1\ mol\ NO}{4\ mol\ HCl}\right)\left(\frac{30.0\ g}{1\ mol\ NO}\right) = 8.22\ g\ NO$

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

$\therefore$ 14.0 g 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:

$14.0\ g\ KNO_3 \left(\frac{1\ mol\ KNO_3}{101.1\ g}\right)\left(\frac{3\ mol\ FeCl_2}{1\ mol\ KNO_3}\right)\left(\frac{126.8\ g}{1\ mol\ FeCl_2}\right) = 52.7\ g\ FeCl_2$

$14.0\ g\ KNO_3 \left(\frac{1\ mol\ KNO_3}{101.1\ g}\right)\left(\frac{4\ mol\ HCl}{1\ mol\ KNO_3}\right)\left(\frac{36.5\ g}{1\ mol\ HCl}\right) = 20.2\ g\ HCl$

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

left over = have − used

$\therefore$ $FeCl_2 \rightarrow 56.8\ g\ FeCl_2 - 52.7\ g\ FeCl_2 = 4.1\ g\ FeCl_2$

$HCl \rightarrow 40.0\ g\ HCl - 20.2\ g\ HCl = 19.8\ g\ HCl$

Ex: 26 - 32 pgs 133 - 134