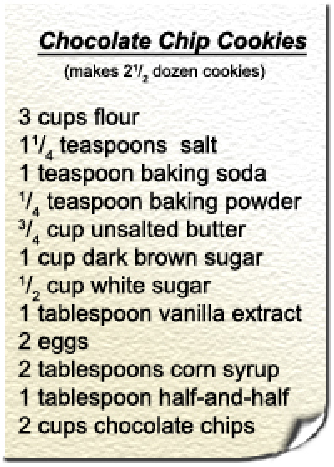
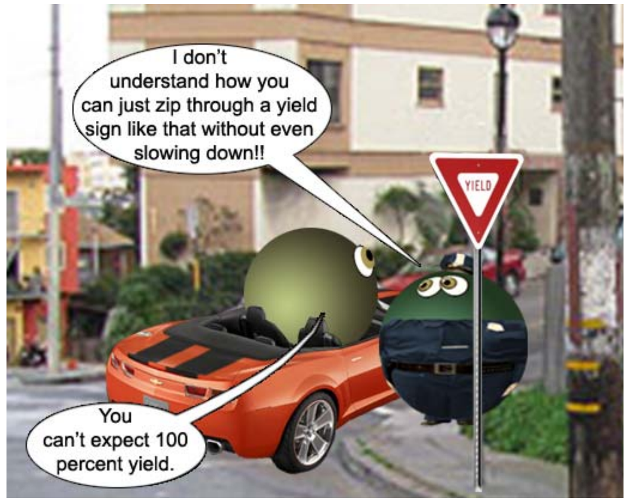
Chemistry: Form WS5.13.1A Name ____________________________

CHEMICAL FORMULAS AND EQUATIONS Date ________________ Period _____

# Percent Yield

You are making chocolate chip cookies. The recipe calls for two eggs to make 2½ dozen cookies. You have only one egg. There is no choice but to make half a recipe. The next problem is that your oven doesn't heat evenly, so the cookies towards the back are always better done than the ones in front. You pop them into the oven and hope for the best. In the end, the three cookies in the back row are burnt beyond recognition, but the rest are good. By scaling back the recipe, you could have theoretically anticipated having 15 cookies, but you only have 12 that are edible. Your yield is only 80 percent of what you anticipated. The same thing happens in chemistry.




**Why atoms make notoriously poor drivers**.

In chemical reactions, the actual yield is usually less than the theoretical yield due to side reactions and other complications. The theoretical yield is the amount of product formed when the limiting reactant is completely consumed. It is the maximum amount of product that can be produced. The actual yield is often expressed as a percentage of the theoretical yield called the percent yield.

$$percent\ \ yield = \frac{actual\ \ yield}{theoretical\ \ yield} \times 100$$

Sample Problem

If 68.5 kg of CO reacts with 8.60 kg of $H_2$ to produce 35.7 kg of $CH_3OH$, what is the percent yield?

Step 1: Write a balanced equation.

$2H_2(g) + CO(g) \rightarrow CH_3OH(\ell)$

Step 2: Identify the limiting reactant

$$\left(8.60kg_{H_2}\right)\left(\frac{1000g}{1kg}\right)\left(\frac{1mol_{H_2}}{2.02g_{H_2}}\right) = 4.26\times10^3 mol_{H_2} \qquad \frac{4.26\times10^3 mol_{H_2}}{2} = 2.13\times10^3 mol_{H_2}$$

$$\left(68.5kg_{CO}\right)\left(\frac{1000g}{1kg}\right)\left(\frac{1mol_{CO}}{28.0g_{CO}}\right) = 2.45\times10^3 mol_{CO} \qquad \frac{2.45\times10^3 mol_{CO}}{1} = 2.45\times10^3 mol_{CO}$$

$H_2$ *is limiting*

Step 3: Use the limiting reactant to complete the calculation of the theoretical yield

$$\left(4.26\times10^3 mol_{H_2}\right)\left(\frac{1mol_{CH_3OH}}{2mol_{H_2}}\right)\left(\frac{32.04g_{CH_3OH}}{1mol_{CH_3OH}}\right)\left(\frac{1kg}{1000g}\right) = 68.2kg_{CH_3OH}$$

Step 4: Calculate the percent yield

$$\frac{35.7kg_{CH_3OH}}{68.2kg_{CH_3OH}} \times 100 = 52.3\%$$

(CONTINUED ON THE NEXT PAGE)

**Calculate the percent yield in each of the problems below.** (*NOTE*: Equations may not be balanced.)

1. $3.25 \times 10^3$ kg of iron III oxide are treated in a blast furnace with $1.50 \times 10^3$ kg of carbon monoxide to form $1.30 \times 10^3$ kg of pure iron. [$Fe_2O_3 + CO \rightarrow Fe + CO_2$]. What is the percent yield?

2. $6.16 \times 10^2$ kg of nitrogen are reacted with $1.75 \times 10^2$ kg hydrogen under conditions of high temperature and pressure in the presence of a catalyst to produce $1.12 \times 10^2$ kg ammonia. [$N_2 + H_2 \rightarrow NH_3$] What is the percent yield?

3. The explosive, ammonium nitrate, is produced by reacting ammonia with nitric acid ($HNO_3$). [$NH_3 + HNO_3 \rightarrow NH_4NO_3$] If 475 kg of ammonia are reacted with 1,060 kg of nitric acid to produce 1150 kg of ammonium nitrate, what is the percent yield?