note: in chemistry "yield" means to form or "produce"

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# Chemistry 11
# STOICHIOMETRY AND PERCENT YIELD

**Sometimes 100% of the expected amount of products can not be obtained from a chemical reaction.**

**The term Percent yield is used to describe the amount of products that are actually obtained as a percentage of the expected amount.**

**Reasons for less than 100% yield:**

1. all of the reactant might not react (impure)
2. Some of the product is lost (in filter etc.)

$$\frac{\text{actual}}{\text{expected}} \cdot 100 = \textbf{PERCENT YIELD} = \frac{\text{mass of product obtained}}{\text{mass of product expected}} \cdot 100$$

**Example 1: When $\boxed{15.0\text{ g of }CH_4}$ is reacted with an excess of $Cl_2$ according to the reaction:**

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

**a total of $\boxed{29.7\text{ g of }CH_3Cl}$ is formed. What is the percent yield of the reaction?**

**Step 1**: Write out the balanced equation

$$\underline{1}\,CH_4 + Cl_2 \longrightarrow \underline{1}\,CH_3Cl + HCl$$

**Step 2**: Write out the PERCENT YIELD FORMULA and identify what you are looking for

$$P.Y. = \frac{\text{actual}}{\text{expected}} \cdot 100 \longrightarrow \frac{29.7\text{ g }CH_3Cl}{?} \cdot 100$$

**Step 3:** Identify the ACTUAL amount produced:

29.7 g $CH_3Cl$

**Step 4**: Calculate the EXPECTED amount using STOICHIOMETRY → g $CH_3Cl$

$$15.0\,\cancel{g\,CH_4}\left(\frac{1\,\cancel{mol\,CH_4}}{16.0\,\cancel{g\,CH_4}}\right)\left(\frac{1\,mol\,CH_3Cl}{1\,\cancel{mol\,CH_4}}\right)\left(\frac{50.5\,g\,CH_3Cl}{1\,mol\,CH_3Cl}\right) = 47.3\,g\,CH_3Cl$$

**Step 5:** Plug the ACTUAL and EXPECTED into the formula

$$P.Y. = \frac{29.7\,g\,CH_3Cl}{47.3\,g\,CH_3Cl} \cdot 100 = \boxed{62.8\%}$$

**Example 2: What mass of $K_2CO_3$ is produced when 1.50 g of $KO_2$ is reacted with an excess of $CO_2$ according to the reaction:**

$$4\,KO_2\,(s) + 2\,CO_2\,(g) \rightarrow 2\,K_2CO_3\,(s) + 3\,O_2\,(g)$$

**If the reaction has a 76.0 % yield?**

**Step 1**: Write out the balanced equation

$$4\,KO_2\,(s) + 2\,CO_2\,(g) \rightarrow 2\,K_2CO_3\,(s) + 3\,O_2\,(g)$$

**Step 2**: Write out the PERCENT YIELD FORMULA and identify what you are looking for

$$76.0\% = \frac{actual}{expected} \cdot 100 \rightarrow 0.760 = \frac{actual}{\underset{*}{expected}}$$

**Step 3**: Calculate the EXPECTED amount using STOICHIOMETRY

$$1.50\,g\,KO_2 \left(\frac{1\,mol\,KO_2}{71.1\,g\,KO_2}\right)\left(\frac{2\,mol\,K_2CO_3}{4\,mol\,KO_2}\right)\left(\frac{138.2\,g}{1\,mol\,K_2CO_3}\right) = \underset{expected}{1.46\,g\,K_2CO_3}$$

**Step 4**: Now use the Percent Yield Formula + expected to solve for ACTUAL

$$1.46(0.760) = \left(\frac{x\,g\,K_2CO_3}{\cancel{1.46\,g}\,K_2CO_3}\right)\cancel{1.46} \rightarrow \boxed{1.11\,g\,K_2CO_3}$$

**Example 3: What mass of CuO is required to make 10.0 g of Cu according to the reaction:** $2\,NH_3 + 3\,CuO \rightarrow N_2 + 3\,Cu + 3\,H_2O$

**IF the reaction has a 58.0 % yield?**

**Step 1**: Write out the balanced equation

$$2\,NH_3 + 3\,CuO \rightarrow N_2 + 3\,Cu + 3\,H_2O$$

**Step 2**: Write out the PERCENT YIELD FORMULA and identify what you are looking for

$$\frac{58.0\%}{100} = \frac{actual}{expected} \cdot \frac{100}{100} \rightarrow 0.580 = \frac{10.0\,g\,Cu}{\underline{\underline{x}}\,g\,Cu}$$

**Step 3**: Re-arrange the FORMULA to solve for EXPECTED Cu

$$x\,g\,Cu(0.580) = \left(\frac{10.0\,g\,Cu}{\cancel{x\,g\,Cu}}\right)\cancel{x\,g\,Cu} \rightarrow \frac{x\,g\,Cu(0.580)}{0.580} = \frac{10.0\,g\,Cu}{0.580}$$

$$x\,g\,Cu = \boxed{17.2\,g\,Cu}\ exp$$

**Step 4**:Use the Expected Cu to solve for the required amount of CuO (STOICH)

$$17.2\,g\,Cu\left(\frac{1\,mol\,Cu}{63.5\,g\,Cu}\right)\left(\frac{3\,mol\,CuO}{3\,mol\,Cu}\right)\left(\frac{79.5\,g\,CuO}{1\,mol\,CuO}\right) = \boxed{21.6\,g\,CuO}$$

Ex: 35-37 pg 137