Stoichiometry Part 3: Limiting Reactant and Percent Yield

Consider the following chemical equation to answer the questions.

$CaCN_2$ (s) + H_2O (l) → $CaCO_3$ (s) + NH_3 (g)

a) Check to see if the equation is balanced. If not, balance it.

$CaCN_2$ (s) + **3** H_2O (l) → $CaCO_3$ (s) + **2** NH_3 (g)

b) Which is the limiting reagent if 23.25 g of $CaCN_2$ is reacted with 30.00 g of water? (show work)

First, determine the number of moles of $CaCO_3$ or NH_3 produced from each reactant. Here I use $CaCO_3$.

$$23.25\ g\ CaCN_2 \times \frac{1\ mol\ \ CaCN_2}{80.102\ g} \times \frac{1\ mol\ CaCO_3}{1\ mol\ \ CaCN_2} = 0.2903\ mol\ CaCO_3$$

$$30.00\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\ g} \times \frac{1\ mol\ CaCO_3}{3\ mol\ H_2O} = 0.5549\ mol\ CaCO_3$$

$CaCN_2$ is the limiting reagent. Only 0.2903 mol $CaCO_3$ can be produced.

c) How many grams of $CaCO_3$ are produced?

mol → g and 1 mole of $CaCO_3$ = 100.0869 g

$$0.2903\ mol\ CaCO_3 \times \frac{100.0869\ g\ CaCO_3}{1\ mol\ CaCO_3} = \mathbf{29.06\ g\ CaCO_3}$$

d) What is the percent yield if 27.34 g of $CaCO_3$ was recovered?

$$\%yield = \frac{actual\ yield}{theoretical\ yield} \times 100 = \frac{27.34\ g}{29.06\ g} \times 100 = \mathbf{94.1}\%$$

e) How much water was left unreacted?

There are several ways to do this problem. I use mole ratios. I will use the mole ratio of $CaCO_3$ to H_2O to determine how much water is needed in the reaction. Then I subtract the amount of water required from the total amount given in the problem.

Mole Ratios: $\frac{3\ mol\ H_2O}{1\ mol\ CaCO_3}$ or $\frac{1\ mol\ CaCO_3}{3\ mol\ H_2O}$ and 1 mol H_2O = 18.02 g

$$0.2903\ mol\ CaCO_3 \times \frac{3\ mol\ \ H_2O}{mol\ CaCO_3} \times \frac{18.02\ g\ \ H_2O}{1\ mol\ \ H_2O} = 15.69\ g\ \ H_2O\ \ needed\ for\ reaction$$

30.00 g H_2O – 15.69 g H_2O = **14.31 g H_2O not reacted**