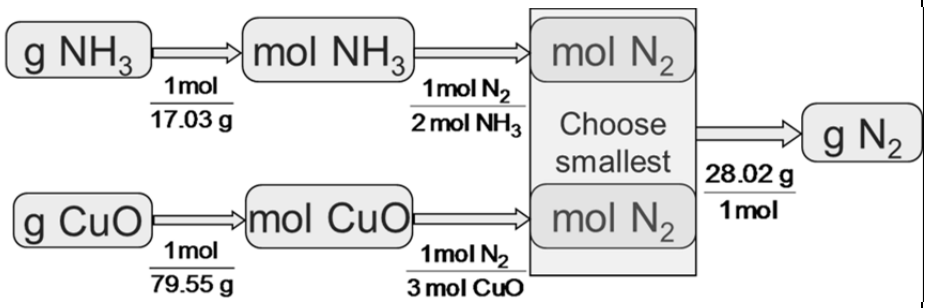
Limiting Reactant & Theoretical Yield

- The reactant that limits the amount of product is called the **limiting reactant or limiting reagent.**
- Reactants not completely consumed are called **excess reactants.**
- The amount of product that can be made from the limiting reactant is called the **theoretical yield**

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100\ \%$$

How many grams of $N_2(g)$ can be made from 9.05 g of NH_3 reacting with 45.2 g of CuO? If 4.61 g of N_2 are made, what is the percent yield?

$2\ NH_3(g) + 3\ CuO(s) \rightarrow N_2(g) + 3\ Cu(s) + 3\ H_2O(l)$

Given **Find**	**9.05 g NH_3, 45.2 g CuO** **g N_2**
Conceptual Plan:	
Relationships:	1 mol NH_3 = 17.03g, 1 mol CuO = 79.55g, 1 mol N_2 = 28.02 g 2 mol NH_3 : 1 mol N_2, 3 mol CuO : 1 mol N_2

Solution:

$$9.05\ \text{g NH}_3 \times \frac{1\ \text{mol NH}_3}{17.03\ \text{g NH}_3} \times \frac{1\ \text{mol N}_2}{2\ \text{mol NH}_3} = 0.2657\ \text{mol N}_2$$

$$45.2\ \text{g CuO} \times \frac{1\ \text{mol CuO}}{79.55\ \text{g CuO}} \times \frac{1\ \text{mol N}_2}{3\ \text{mol CuO}} = 0.1894\ \text{mol N}_2$$

limiting reactant — **smallest moles of N_2**

$$0.1894\ \text{mol N}_2 \times \frac{28.02\ \text{g N}_2}{1\ \text{mol N}_2} = 5.31\ \text{g N}_2$$

theoretical yield

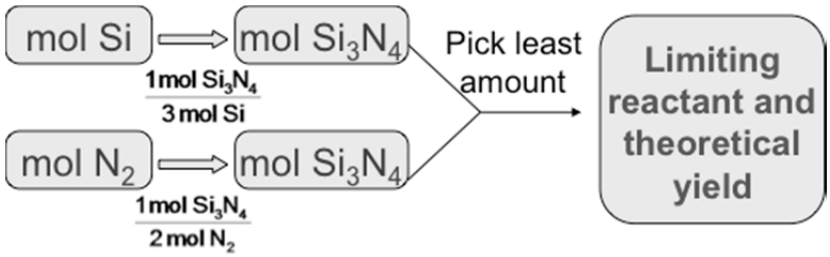
$$\text{Percent Yield} = \frac{4.61\,\text{g}\,N_2}{5.31\,\text{g}\,N_2} \times 100\% = 86.8\%\ \text{Yield}$$

Practice Problems

1. How many moles of Si_3N_4 can be made from 1.20 moles of Si and 1.00 moles of N_2 in the reaction?

$$3\ Si + 2\ N_2 \longrightarrow Si_3N_4$$

Conceptual Plan



2. A strip of zinc metal having a mass of 2.00 g is placed in an aqueous solution containing 2.50 g of silver nitrate, causing the following reaction to occur;

$$Zn\ (s)\ +\ 2\ AgNO_3\ (aq) \longrightarrow 2\ Ag\ (s)\ +\ Zn(NO_3)_2\ (aq)$$

(a) Which reactant is limiting?

(b) How many grams of Ag will form?

(c) How many grams of $Zn(NO_3)_2$ will form?

(d) If you obtain 1.32 g of Ag from your reaction, what is the percent yield of silver?

References:

Tro, Chemistry: A Molecular Approach 2nd ed., Pearson

Brown/LeMay/Bursten, Chemistry: The Central Science, 12th ed., Pearson

Answers

1. 0.400 mol Si_3N_4

2. (a) $AgNO_3$; (b) 1.59 g; (c) 1.39 g; (d) 83.0%