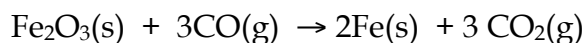


## Stoichiometry-Activity 3, Limiting Reagents KEY

1. Solid iron (III) oxide reacts with carbon monoxide gas to form iron solid and carbon dioxide gas. If 187 g of iron (III) oxide is allowed to react with 105.8 grams of carbon monoxide, how many grams of iron can be generated?



$$\text{Fe}_2\text{O}_3: 187\text{g Fe}_2\text{O}_3 \times \frac{1 \text{ mol Fe}_2\text{O}_3}{159.7 \text{ g Fe}_2\text{O}_3} \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{55.845 \text{ g Fe}}{1 \text{ mol Fe}} = 131 \text{ g Fe}$$

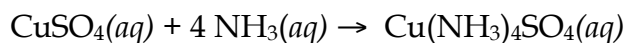
$$\text{CO}: 105.8 \text{ CO} \times \frac{1 \text{ mol CO}}{28.01 \text{ g CO}} \times \frac{2 \text{ mol Fe}}{3 \text{ mol CO}} \times \frac{55.845 \text{ g Fe}}{1 \text{ mol Fe}} = 140.6 \text{ g Fe}$$

$\text{Fe}_2\text{O}_3$  is the limiting reactant, so the maximum amount of Fe generated is 131 g Fe.

2. If only 99.0 g of iron is generated, what is the percent yield of iron?

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{99.0\text{g Fe}}{131\text{g Fe}} \times 100 = 75.6\%$$

3. The deep blue  $\text{Cu}(\text{NH}_3)_4\text{SO}_4$  is made by the reaction of copper (II) sulfate with ammonia, as described by the following reaction:



- a) If you use 10.0g of ammonia and 20.0g of copper(II) sulfate, what is the theoretical yield for the reaction?

$$10.0 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.03 \text{ g}} \times \frac{1 \text{ mol Cu}(\text{NH}_3)_4\text{SO}_4}{4 \text{ mol NH}_3} \times \frac{227.756 \text{ g Cu}(\text{NH}_3)_4\text{SO}_4}{1 \text{ mol}} = 33.4 \text{ g Cu}(\text{NH}_3)_4\text{SO}_4$$

$$20.0 \text{ g CuSO}_4 \times \frac{1 \text{ mol CuSO}_4}{159.62 \text{ g CuSO}_4} \times \frac{1 \text{ mol Cu}(\text{NH}_3)_4\text{SO}_4}{1 \text{ mol CuSO}_4} \times \frac{227.756 \text{ g Cu}(\text{NH}_3)_4\text{SO}_4}{1 \text{ mol}} = 28.5 \text{ g Cu}(\text{NH}_3)_4\text{SO}_4$$

So,  $\text{CuSO}_4$  is the limiting reagent and 28.5g of  $\text{Cu}(\text{NH}_3)_4\text{SO}_4$  can be made.

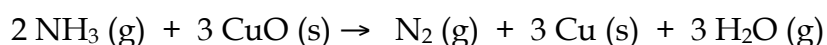
- b) If 18.6 g of  $\text{Cu}(\text{NH}_3)_4\text{SO}_4$  is isolated at the end of the reaction, what is the percent yield for the reaction?

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical (calculated) yield}} \times 100\% = \frac{18.6\text{g}}{28.5\text{g}} \times 100\% = 65.3\%$$

## Stoichiometry-Activity 3, Limiting Reagents

## KEY

4. Nitrogen gas can be prepared by passing gaseous ammonia over solid copper (II) oxide at high temperatures, as described by the following *balanced* equation.



- a) How many grams of  $\text{N}_2$  are formed when 18.1 g of  $\text{NH}_3$  are reacted with 90.4 g of  $\text{CuO}$ ?

$$18.1 \text{ g NH}_3 \times \frac{1 \text{ mol}}{17.03 \text{ g NH}_3} \times \frac{1 \text{ mol N}_2}{2 \text{ mol NH}_3} \times \frac{28.01 \text{ g N}_2}{1 \text{ mol N}_2} = 14.9 \text{ g N}_2$$

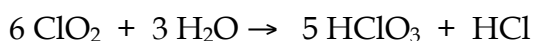
$$90.4 \text{ g CuO} \times \frac{1 \text{ mol CuO}}{79.55 \text{ g CuO}} \times \frac{1 \text{ mol N}_2}{3 \text{ mol CuO}} \times \frac{28.01 \text{ g N}_2}{1 \text{ mol N}_2} = 10.6 \text{ g N}_2 \leftarrow \text{Limiting Reagent!}$$

- b) What starting material, if any is left over? How many grams of that material are left over?

$$10.6 \text{ g N}_2 \times \frac{1 \text{ mole N}_2}{28.02 \text{ g N}_2} \times \frac{2 \text{ mole NH}_3}{1 \text{ mole N}_2} \times \frac{17.03 \text{ g NH}_3}{1 \text{ mole NH}_3} = 12.9 \text{ g NH}_3 \text{ used}$$

Thus, if 12.9 g of  $\text{NH}_3$  is used, then  $18.1\text{g} - 12.9\text{g} = 5.2\text{g}$   $\text{NH}_3$  is left over.

5. Chlorine dioxide is used as a disinfectant and bleaching agent. In water, it reacts to form chloric acid ( $\text{HClO}_3$ ), according to the following *balanced* equation:



- a) If 142.0 g of  $\text{ClO}_2$  are mixed with 38.0 g of  $\text{H}_2\text{O}$ , how many grams of chloric acid are formed?

$$142.0 \text{ g ClO}_2 \times \frac{1 \text{ mol ClO}_2}{67.45 \text{ g ClO}_2} \times \frac{5 \text{ mol HClO}_3}{6 \text{ mol ClO}_2} \times \frac{84.46 \text{ g HClO}_3}{1 \text{ mol HClO}_3} = 148.1 \text{ g HClO}_3$$

$$38.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.01 \text{ g H}_2\text{O}} \times \frac{5 \text{ mol HClO}_3}{3 \text{ mol H}_2\text{O}} \times \frac{84.46 \text{ g HClO}_3}{1 \text{ mol HClO}_3} = 296 \text{ g HClO}_3$$

$\text{ClO}_2$  is the limiting reagent, so only 148.1 g can be formed.

- b) What is the percent yield for the reaction if 120.2 g of chloric acid is actually produced?

$$\frac{120.2 \text{ g}}{148.1 \text{ g}} \times 100\% = 81.16\%$$