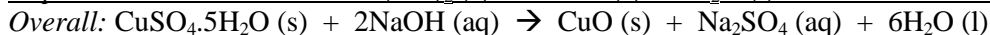
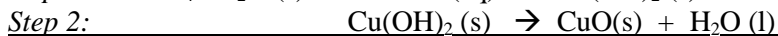
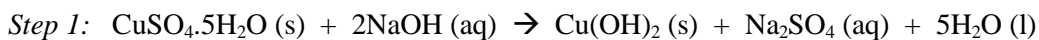


**CHEM 101-080 Fall 2004**  
**Problem-Solving Session 4a**  
**Chapter 8**  
**October 20, 2004**

**Ch. 8: Chemical Reactions - Example from Lab 14**



**Q1:** Given 2.0 grams of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  (FW=249.68 g/mol) with an excess of NaOH, how much  $\text{Cu}(\text{OH})_2$  (FW=97.56 g/mol) will be produced?

**S1:**

$$2.0 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}}{249.68 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{1 \text{ mol } \text{Cu}(\text{OH})_2}{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{97.56 \text{ g } \text{Cu}(\text{OH})_2}{1 \text{ mol } \text{Cu}(\text{OH})_2} = 0.781 \text{ g } \text{Cu}(\text{OH})_2$$

**Q2:** Given Q1, how much  $\text{Na}_2\text{SO}_4$  (FW=142.04 g/mol) will be produced?

**S2:**

$$2.0 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}}{249.68 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{1 \text{ mol } \text{Na}_2\text{SO}_4}{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{142.04 \text{ g } \text{Na}_2\text{SO}_4}{1 \text{ mol } \text{Na}_2\text{SO}_4} = 1.14 \text{ g } \text{Na}_2\text{SO}_4$$

**Q3:** Given Q1, how much  $\text{H}_2\text{O}$  (FW=18.02 g/mol) will be produced?

**S3:**

$$2.0 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}}{249.68 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{5 \text{ mol } \text{H}_2\text{O}}{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{18.02 \text{ g } \text{H}_2\text{O}}{1 \text{ mol } \text{H}_2\text{O}} = 0.722 \text{ g } \text{H}_2\text{O}$$

**Q4:** Given Q1, how much  $\text{CuO}$  (FW=79.55 g/mol) will be produced?

**S4:**

$$2.0 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}}{249.68 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{1 \text{ mol } \text{CuO}}{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{79.55 \text{ g } \text{CuO}}{1 \text{ mol } \text{CuO}} = 0.637 \text{ g } \text{CuO}$$

**Q5:** Suppose that 10% of the  $\text{Cu}(\text{OH})_2$  was accidentally lost. Now how much  $\text{CuO}$  (FW=79.55 g/mol) will be produced?

**S5:** From Q1: Ideally, we'd have 0.781 g  $\text{Cu}(\text{OH})_2$   
If 10% is lost, then we have  $0.781 \text{ g} * 0.90 = 0.7029 \text{ g}$   $\text{Cu}(\text{OH})_2$  remaining

$$0.7029 \text{ g } \text{Cu}(\text{OH})_2 \times \frac{\text{mol } \text{Cu}(\text{OH})_2}{97.56 \text{ g } \text{Cu}(\text{OH})_2} \times \frac{1 \text{ mol } \text{CuO}}{1 \text{ mol } \text{Cu}(\text{OH})_2} \times \frac{79.55 \text{ g } \text{CuO}}{1 \text{ mol } \text{CuO}} = 0.573 \text{ g } \text{CuO}$$

**Sec. 8-7 Limiting Reactant (p. 234):** The reactant that produces the least amount of product

**Q6:** Suppose that 10.0 ml of 6M NaOH (i.e. 6.0 moles NaOH/liter) is used. How much  $\text{CuO}$  (FW=79.55 g/mol) will be produced? What is the limiting reactant?

**S6:** From Q4: Ideally, we'll have 0.637 g  $\text{CuO}$  - if  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  completely reacts.  
If NaOH is the LR, then we'll have less  $\text{CuO}$ .

*Amount from  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ :* 0.637 g  $\text{CuO}$

*Amount from NaOH:*

$$10.0 \text{ ml NaOH} \times \frac{1}{1000 \text{ ml}} \times \frac{6 \text{ mols NaOH}}{1} = 0.0600 \text{ mol NaOH}$$

$$0.0600 \text{ mol NaOH} \times \frac{\text{mol } \text{CuO}}{2 \text{ mol NaOH}} \times \frac{79.55 \text{ g } \text{CuO}}{1 \text{ mol } \text{CuO}} = 2.39 \text{ g } \text{CuO}$$

*Result: because  $0.637 < 2.39$ ,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  is the LR:*

**OR**

Note from reaction Step 2: NaOH and  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  react in a 1:2 molar ratio.

*Calculate moles of each:*

$$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}: 2.0 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{\text{mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}}{249.68 \text{ g } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} = 0.00801 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}$$

*Moles NaOH needed:*

$$0.00801 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol } \text{CuSO}_4 \cdot 5\text{H}_2\text{O}} = 0.01602 \text{ mol NaOH}$$

$$\text{NaOH present: } 10.0 \text{ ml NaOH} \times \frac{1}{1000 \text{ ml}} \times \frac{6 \text{ mols NaOH}}{1} = 0.0600 \text{ mol NaOH}$$

*Result: because  $0.0600 > 0.01602$ , NaOH is present in excess and the LR is  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ .*

**Sec. 8-8 Percent Yield (p. 238):** Compare "Actual" (g), "Theoretical" (g), and "%" (ratio) yields

**Q7:** What is the theoretical yield of CuO given Q1?

**S7:** 0.637 g CuO (from S4)

**Q8:** If 0.625 g CuO is produced, what are the actual and theoretical yields given Q1?

**S8:** Actual yield = 0.625 g CuO, Percent yield =  $100 \times (0.625/0.637) = 98.1\%$