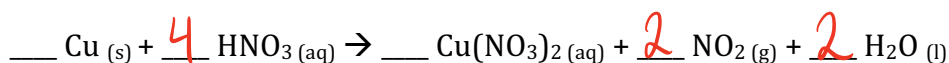


Copper Cycle Stoichiometry

Show all steps and calculations in the space provided below.

1. Consider the reaction below, which is the first step in the process of recycling copper



- a. If a student began the experiment with 0.020g of copper metal, what volume (in mL) of 15.8M HNO₃ would be required to complete the reaction?

$$0.020 \text{ g Cu} \times \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} \times \frac{4 \text{ mol HNO}_3}{1 \text{ mol Cu}} \times \frac{1 \text{ L HNO}_3}{15.8 \text{ mol HNO}_3} \times \frac{1000 \text{ mL HNO}_3}{1 \text{ L HNO}_3} = \boxed{0.080 \text{ mL HNO}_3}$$

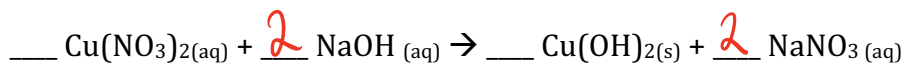
- b. How many mL of NO₂ gas would be produced in the reaction was carried out at STP?

$$0.020 \text{ g Cu} \times \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} \times \frac{2 \text{ mol NO}_2}{1 \text{ mol Cu}} \times \frac{22.4 \text{ L NO}_2}{1 \text{ mol NO}_2} \times \frac{1000 \text{ mL NO}_2}{1 \text{ L NO}_2} = \boxed{14 \text{ mL NO}_2}$$

- c. How much Cu(NO₃)₂ (in grams) would be produced?

$$0.020 \text{ g Cu} \times \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} \times \frac{1 \text{ mol Cu(NO}_3)_2}{1 \text{ mol Cu}} \times \frac{187.57 \text{ g Cu(NO}_3)_2}{1 \text{ mol Cu(NO}_3)_2} = \boxed{0.059 \text{ g Cu(NO}_3)_2}$$

2. The next step in the process follows the reaction below:



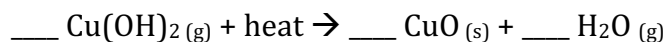
- a. If all of the Cu(NO₃)₂ produced in question 1 was used, what would be the mass of the solid produced in the reaction above?

$$0.059 \text{ g Cu(NO}_3)_2 \times \frac{1 \text{ mol Cu(NO}_3)_2}{187.57 \text{ g Cu(NO}_3)_2} \times \frac{1 \text{ mol Cu(OH)}_2}{1 \text{ mol Cu(NO}_3)_2} \times \frac{97.57 \text{ g Cu(OH)}_2}{1 \text{ mol Cu(OH)}_2} = \boxed{0.031 \text{ g Cu(OH)}_2}$$

- b. How much base (mL of 0.10M NaOH) would be needed in order to have a complete reaction?

$$0.059 \text{ g Cu(NO}_3)_2 \times \frac{1 \text{ mol Cu(NO}_3)_2}{187.57 \text{ g Cu(NO}_3)_2} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol Cu(NO}_3)_2} \times \frac{1 \text{ L NaOH}}{0.10 \text{ mol NaOH}} \times \frac{1000 \text{ mL NaOH}}{1 \text{ L NaOH}} = \boxed{6.3 \text{ mL NaOH}}$$

3. The solid copper (II) hydroxide decomposes in heat to form copper (II) oxide and steam according to the reaction below

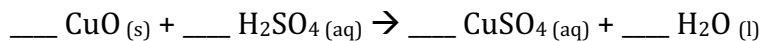


What mass of solid CuO would result if the reaction went to completion?

From 2.a.

$$0.031 \text{ g Cu(OH)}_2 \times \frac{1 \text{ mol Cu(OH)}_2}{97.57 \text{ g Cu(OH)}_2} \times \frac{1 \text{ mol CuO}}{1 \text{ mol Cu(OH)}_2} \times \frac{79.85 \text{ g CuO}}{1 \text{ mol CuO}} = \boxed{0.025 \text{ g CuO}}$$

4. When reacted with sulphuric acid (H₂SO₄), the reaction follows the following equation:



a. What volume in milliliters of 6.0 M sulphuric acid (H₂SO₄) would be needed to fully react with the CuO produced in question 3?

$$0.025 \text{ g CuO} \times \frac{1 \text{ mol CuO}}{79.85 \text{ g CuO}} \times \frac{1 \text{ mol H}_2\text{SO}_4}{1 \text{ mol CuO}} \times \frac{1 \text{ L H}_2\text{SO}_4}{6.0 \text{ mol H}_2\text{SO}_4} \times \frac{1000 \text{ mL}}{1 \text{ L}} = \boxed{0.052 \text{ mL H}_2\text{SO}_4}$$

b. What mass of copper (II) sulphate (CuSO₄) would be in solution at the end of the reaction?

$$0.025 \text{ g CuO} \times \frac{1 \text{ mol CuO}}{79.85 \text{ g CuO}} \times \frac{1 \text{ mol CuSO}_4}{1 \text{ mol CuO}} \times \frac{159.62 \text{ g CuSO}_4}{1 \text{ mol CuSO}_4} = \boxed{0.050 \text{ g CuSO}_4}$$

5. In the final step of the process, solid copper metal is reformed using magnesium metal, according to the following reaction (complete the reaction):



a. What mass of MgSO₄ would be produced in this reaction?

From 4.b. ↘

$$0.050 \text{ g CuSO}_4 \times \frac{1 \text{ mol CuSO}_4}{159.62 \text{ g CuSO}_4} \times \frac{1 \text{ mol MgSO}_4}{1 \text{ mol CuSO}_4} \times \frac{120.38 \text{ g MgSO}_4}{1 \text{ mol MgSO}_4} = \boxed{0.038 \text{ g MgSO}_4}$$

b. What is the minimum mass of magnesium metal that could be used in this reaction?

$$0.050 \text{ g CuSO}_4 \times \frac{1 \text{ mol CuSO}_4}{159.62 \text{ g CuSO}_4} \times \frac{1 \text{ mol Mg}}{1 \text{ mol CuSO}_4} \times \frac{24.31 \text{ g Mg}}{1 \text{ mol Mg}} = \boxed{0.0076 \text{ g Mg}}$$

c. What should the final mass of copper metal be? How does this mass compare to the starting mass of copper metal in question 1?

$$0.050 \text{ g CuSO}_4 \times \frac{1 \text{ mol CuSO}_4}{159.62 \text{ g CuSO}_4} \times \frac{1 \text{ mol Cu}}{1 \text{ mol CuSO}_4} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = \boxed{0.020 \text{ g Cu}}$$

It's the same as the starting mass!