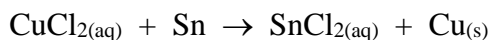


Reaction Stoichiometry III

Yield, Concentration, and Solution Stoichiometry

1. If 5.05 g of CuCl_2 reacts with excess tin, what mass of copper is expected from the reaction?



$$M_{\text{CuCl}_2} = 134.45 \frac{\text{g}}{\text{mol}} \quad M_{\text{Cu}} = 63.546 \frac{\text{g}}{\text{mol}}$$

$$m_{\text{Sn}} = \left(\frac{5.05 \text{ g CuCl}_2}{134.45 \frac{\text{g CuCl}_2}{\text{mol CuCl}_2}} \right) \times \frac{1 \text{ mol Cu}}{1 \text{ mol CuCl}_2} \times 63.546 \frac{\text{g}}{\text{mol}}$$

$$m_{\text{Sn}} = 2.39 \text{ g Cu (Theoretical Yield)}$$

What is the percentage yield if only 2.20 g of Cu is recovered? Where did the lost product go?

$$\% \text{ yield} = \frac{2.20 \text{ g}}{2.39 \text{ g}} \times 100 = 92.2\% \text{ yield}$$

2. What is the molar concentration of a solution prepared by dissolving 5.84 g of NaCl in sufficient water to make 1.0 L of solution?

$$M_{\text{NaCl}} = 58.44 \frac{\text{g}}{\text{mol}} \quad \text{definition: } C = \frac{n_{\text{NaCl}}}{V_{\text{soln}}}$$

$$n_{\text{NaCl}} = \frac{5.84 \text{ g}}{58.44 \frac{\text{g}}{\text{mol}}} = 0.09993 \text{ mol NaCl}$$

$$C = \frac{0.09993 \text{ mol NaCl}}{1.0 \text{ L}} = 0.10 \text{ M NaCl}$$

$$\text{Also written: } 0.10 \frac{\text{mol}}{\text{L}} \text{ and } 0.10 \text{ mol L}^{-1}$$

3. What mass of NaOH is necessary to prepare 500.0 mL of 0.250 M NaOH? (molar mass of NaOH = 40.00 g/mol)

$$C = \frac{n}{V}$$

$$n_{\text{NaOH}} = 0.250 \frac{\text{mol NaOH}}{\text{L soln}} \times 0.5000 \text{ L} = 0.125 \text{ mol NaOH}$$

$$m_{\text{NaOH}} = 0.125 \text{ mol NaOH} \times 40.00 \frac{\text{g NaOH}}{\text{mol NaOH}} = 5.00 \text{ g NaOH}$$

4. What quantity, in moles, of HCl are present in 10.00 mL of 0.125 M HCl? What would the new HCl concentration be if 10.00 mL of water were added to the original 10.00 mL of 0.125 M HCl?

$$n_{\text{HCl}} = 0.01000 \text{ L} \times 0.125 \frac{\text{mol HCl}}{\text{L soln}} = 1.25 \times 10^{-3} \text{ mol HCl}$$

$$C_{\text{new}} = \frac{1.25 \times 10^{-3} \text{ mol HCl}}{0.02000 \text{ L}} = 0.0625 \text{ M HCl}$$

5. What is the concentration of the solution prepared by diluting 10.00 mL of 0.125 M HCl to 40.00 mL?

$$C_1 V_1 = C_2 V_2$$

$$C_{\text{new}} = \frac{(10.00 \text{ mL})(0.125 \text{ M})}{40.00 \text{ mL}} = 0.0313 \text{ M HCl}$$

6. How might you prepare 500.0 mL of 0.10 M HCl from concentrated HCl (12 M)?

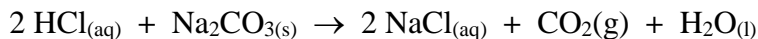
1. Use the dilution equation to calculate the need volume of concentrated acid:

$$C_{\text{conc'd acid}} V_{\text{conc'd acid}} = C_{\text{dilution}} V_{\text{dilution}}$$

$$V_{\text{conc'd acid}} = \frac{500.0 \text{ mL} \times 0.10 \text{ M}}{12 \text{ M}} = 4.2 \text{ mL}$$

2. Pipette about 4 mL of concentrated HCl into a 500 mL volumetric flask and dilute up to the 500 mL mark with water.

7. What volume (in mL) of 0.15 M HCl will react with 2.50 g of Na_2CO_3 according to the equation



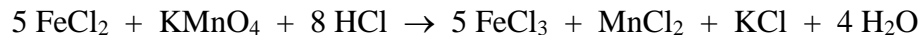
$$M_{\text{Na}_2\text{CO}_3} = 105.99 \frac{\text{g}}{\text{mol}}$$

$$n_{\text{Na}_2\text{CO}_3} = 2.50 \text{ g Na}_2\text{CO}_3 \times \frac{1 \text{ mol Na}_2\text{CO}_3}{105.99 \text{ g Na}_2\text{CO}_3} = 0.02359 \text{ mol Na}_2\text{CO}_3$$

$$n_{\text{HCl}} = 0.02359 \text{ mol Na}_2\text{CO}_3 \times \frac{2 \text{ mol HCl}}{1 \text{ mol Na}_2\text{CO}_3} = 0.04717 \text{ mol HCl}$$

$$V_{\text{HCl}} = 0.04717 \text{ mol HCl} \times \frac{1 \text{ L soln}}{0.15 \text{ mol HCl}} \times 1000 \frac{\text{mL}}{\text{L}} = 314 \text{ mL HCl solution}$$

8. What is the concentration of a KMnO_4 solution if 15.16 mL of the KMnO_4 solution is required to titrate to equivalence point 25.00 mL of 0.08765 M FeCl_2 ?



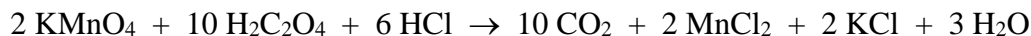
$$n_{\text{FeCl}_2} = 0.02500 \text{ L} \times 0.08765 \frac{\text{mol FeCl}_2}{\text{L soln}} = 0.0021913 \text{ mol FeCl}_2$$

$$n_{\text{KMnO}_4} = 0.0021913 \text{ mol FeCl}_2 \times \frac{1 \text{ mol KMnO}_4}{5 \text{ mol FeCl}_2} = 4.3825 \times 10^{-4} \text{ mol KMnO}_4$$

$$C_{\text{KMnO}_4} = \frac{4.3825 \times 10^{-4} \text{ mol KMnO}_4}{0.01516 \text{ L soln}} = 0.02891 \text{ M KMnO}_4$$

9. What is the percentage purity of a sample of impure oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$, 90.04 g/mol) if 23.42 mL of the KMnO_4 from problem 8 was required to titrate 1.5960 g of the solid?

First, the hard part; write the balanced chemical equation



$$\text{Definition: } \% \text{purity} = \frac{m_{\text{H}_2\text{C}_2\text{O}_4}}{m_{\text{sample}}} \times 100 \quad m_{\text{sample}} = 0.1596 \text{ g}$$

$$n_{\text{KMnO}_4} = 0.02342 \text{ L} \times 0.02891 \text{ M KMnO}_4 = 6.7703 \times 10^{-4} \text{ mol KMnO}_4$$

$$n_{\text{H}_2\text{C}_2\text{O}_4} = 6.7703 \times 10^{-4} \text{ mol KMnO}_4 \times \frac{10 \text{ mol H}_2\text{C}_2\text{O}_4}{2 \text{ mol KMnO}_4} = 3.3852 \times 10^{-3} \text{ mol H}_2\text{C}_2\text{O}_4$$

$$m_{\text{H}_2\text{C}_2\text{O}_4} = 3.3852 \times 10^{-3} \text{ mol H}_2\text{C}_2\text{O}_4 \times 90.04 \frac{\text{g}}{\text{mol}} = 0.3048 \text{ g H}_2\text{C}_2\text{O}_4$$

$$\% \text{purity} = \frac{0.3048 \text{ g}}{1.5960 \text{ g}} \times 100 = 19.10\% \text{ H}_2\text{C}_2\text{O}_4$$