

Problem Set 1 -- Stoichiometry and Concentration Review

Complete all problems on separate paper. Show all work for credit. Correct use of significant figures is required for full credit.

1. Describe how to prepare 2.00 L of a solution that has a chloride concentration of 0.0100 M starting with:

- solid copper (II) chloride
- 0.200 M copper (II) chloride solution.

a.

$$\frac{0.010 \text{ mol Cl}^-}{1 \text{ L}} \times 2.00 \text{ L} \times \frac{1 \text{ mol CuCl}_2}{2 \text{ mol Cl}^-} \times \frac{134.452 \text{ g CuCl}_2}{1 \text{ mol CuCl}_2} = 1.35 \text{ g CuCl}_2$$

So, weigh 1.35 g CuCl₂ and dilute it to 2.00 L.

b.

$$\frac{0.010 \text{ mol Cl}^-}{1 \text{ L}} \times 2.00 \text{ L} \times \frac{1 \text{ mol CuCl}_2}{2 \text{ mol Cl}^-} \times \frac{1 \text{ L}}{0.200 \text{ mol CuCl}_2} = 0.050 \text{ L CuCl}_2$$

So, diluted 0.050 L (50 mL) of 0.200 M CuCl₂ to 2.00 L.

2. When calcium carbonate is added to hydrochloric acid, calcium chloride, carbon dioxide, and water are produced. How many grams of calcium chloride will be produced when 31.0 g of calcium carbonate are combined with 10.0 g of hydrochloric acid?



$$31.0 \text{ g CaCO}_3 \times \frac{1 \text{ mol CaCO}_3}{100.067 \text{ g CaCO}_3} \times \frac{1 \text{ mol CaCl}_2}{1 \text{ mol CaCO}_3} \times \frac{110.984 \text{ g CaCl}_2}{1 \text{ mol CaCl}_2} = 34.37 \text{ g CaCl}_2$$

$$10.0 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.461 \text{ g HCl}} \times \frac{1 \text{ mol CaCl}_2}{2 \text{ mol HCl}} \times \frac{110.984 \text{ g CaCl}_2}{1 \text{ mol CaCl}_2} = 15.22 \text{ g CaCl}_2$$

So, HCl is the limiting reactant and 15.2 g of CaCl₂ will be produced.

3. 0.850 L of 0.490 M sulfuric acid is mixed with 0.800 L of 0.250 M potassium hydroxide. What concentration of sulfuric acid remains after neutralization?



$$0.800 \text{ L KOH} \times \frac{0.250 \text{ mol KOH}}{1 \text{ L KOH}} \times \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol KOH}} = 0.100 \text{ mol H}_2\text{SO}_4 \text{ consumed}$$

$$0.850 \text{ L H}_2\text{SO}_4 \times \frac{0.490 \text{ mol H}_2\text{SO}_4}{1 \text{ L H}_2\text{SO}_4} = 0.4165 \text{ mol H}_2\text{SO}_4 \text{ introduced}$$

$$0.4165 - 0.100 = 0.3165 \text{ mol H}_2\text{SO}_4 \text{ remain} / (0.800 + 0.850) \text{ L} = \mathbf{0.192 \text{ M H}_2\text{SO}_4}$$

4. In the laboratory, you weigh out 0.114 grams of solid $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ (molar mass 241.43 g/mol), dissolve it, and dilute it to a total volume of 100.0 mL to make solution A. You then transfer 3.00 mL of solution A into a 25.0 mL volumetric flask and dilute to the mark to make solution B. What is the concentration of aluminum ion in solution B in moles per liter? In ppm?

Solution A:

$$0.114 \text{ g AlCl}_3 \cdot 6\text{H}_2\text{O} \times \frac{1 \text{ mol AlCl}_3 \cdot 6\text{H}_2\text{O}}{241.43 \text{ g AlCl}_3 \cdot 6\text{H}_2\text{O}} \times \frac{1 \text{ mol Al}^{3+}}{1 \text{ mol AlCl}_3 \cdot 6\text{H}_2\text{O}} \times \frac{1}{0.1000 \text{ L}} = 4.72 \times 10^{-3} \text{ M}$$

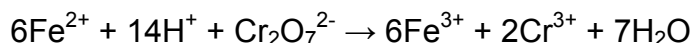
Solution B:

$$3 \text{ mL} \times \frac{4.72 \times 10^{-3} \text{ mol Al}^{3+}}{1 \text{ L}} \times \frac{1}{25 \text{ mL}} = 5.67 \times 10^{-4} \text{ M}$$

In ppm:

$$\frac{5.67 \times 10^{-4} \text{ mol Al}^{3+}}{1 \text{ L}} \times \frac{26.982 \text{ g Al}}{1 \text{ mol}} \times \frac{10^3 \text{ mg}}{1 \text{ g}} = \frac{15.3 \text{ mg Al}}{1 \text{ L}} = 15.3 \text{ ppm}$$

5. An iron ore sample weighing 0.9132 g is dissolved in $\text{HCl}(\text{aq})$, and the iron is obtained as $\text{Fe}^{2+}(\text{aq})$. This solution is then titrated with 28.72 mL of 0.05051 M $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ using the balanced reaction below. What is the mass percent of iron in the iron ore?



$$0.0287 \text{ L} \times \frac{0.05051 \text{ mol Cr}_2\text{O}_7^{2-}}{\text{L}} \times \frac{6 \text{ mol Fe}}{1 \text{ mol Cr}_2\text{O}_7^{2-}} \times \frac{55.845 \text{ g Fe}}{1 \text{ mol Fe}} = 0.4857 \text{ g Fe}$$

$$\frac{0.4857 \text{ g Fe}}{0.9132 \text{ g ore}} \times 100\% = 53.19\% \text{ Fe}$$