1. Classify each of the following reactions as combination, decomposition, acid-base, and/or oxidation-reduction:

(a) \(\text{MgO} \, (s) + 2 \text{HCl} \, (aq) \rightarrow \text{MgCl}_2 \, (aq) + \text{H}_2\text{O} \, (l)\) \hspace{1cm} \text{Acid-base}

(b) \(2 \text{NaHCO}_3 \, (s) \rightarrow \text{Na}_2\text{CO}_3 \, (s) + \text{CO}_2 \, (g) + \text{H}_2\text{O} \, (g)\) \hspace{1cm} \text{Decomposition}

(c) \(\text{CaO} \, (s) + \text{SO}_2 \, (g) \rightarrow \text{CaSO}_3 \, (s)\) \hspace{1cm} \text{Combination}

(d) \(3 \text{Cu} \, (s) + 8 \text{HNO}_3 \, (aq) \rightarrow 3 \text{Cu(NO}_3)_2 \, (aq) + 2 \text{NO} \, (g) + 4 \text{H}_2\text{O} \, (l)\) \hspace{1cm} \text{Redox & acid-base}

(e) \(2 \text{NO} \, (g) + \text{O}_2 \, (g) \rightarrow 2 \text{NO}_2 \, (g)\) \hspace{1cm} \text{Combination & redox}

2. How could you use a precipitation reaction to separate each of the following pairs of anions? Write the formula for each reactant you would add, and write a balanced net ionic equation for each reaction.

a. \(\text{Cl}^-\) and \(\text{NO}_3^-\) \hspace{1cm} \text{Add a soluble silver compound like AgClO}_4 to precipitate Cl\(^-\) as AgCl.}
   \[\text{Ag}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{AgCl(s)}\]

b. \(\text{OH}^-\) and \(\text{ClO}_4^-\) \hspace{1cm} \text{Add a soluble iron compound like FeSO}_4 to precipitate OH\(^-\) as Fe(OH)\(_2\).}
   \[\text{Fe}^{2+}(aq) + 2 \text{OH}^-(aq) \rightarrow \text{Fe(OH)}_2(s)\]

3. Pure acetic acid, known as glacial acetic acid, is a liquid with a density of 1.049 g/mL at 25°C. Calculate the molarity of a solution of acetic acid made by dissolving 20.00 mL of glacial acetic acid at 25°C in enough water to make 250.0 mL of solution. \((\text{acetic acid} = \text{CH}_3\text{COOH})\)

\[
\text{mass of acetic acid} = (20.00 \text{ mL}) \left(\frac{1.049 \text{ g}}{1 \text{ mL}}\right) = 20.98 \text{ g}
\]

\[
\text{moles acetic acid} = \left(\frac{20.98 \text{ g}}{60.0524 \text{ g/mol}}\right) = 0.3494 \text{ mol}
\]

\[
\text{Molarity of acetic acid} = \left(\frac{0.3494 \text{ mol}}{0.2500 \text{ L}}\right) = 1.397 \text{ M}
\]

4. A 25.0-mL sample of 1.00 M KBr and a 75.0-mL sample of 0.800 M KBr are mixed. The solution is then heated to evaporate water until the total volume is 50.0 mL. What is the molarity of the KBr in the final solution?

\[
\text{mol KBr in sample 1} = (0.0250 \text{ L}) \left(\frac{1.00 \text{ mol}}{1 \text{ L}}\right) = 0.0250 \text{ mol}
\]

\[
\text{mol KBr in sample 2} = (0.0750 \text{ L}) \left(\frac{0.800 \text{ mol}}{1 \text{ L}}\right) = 0.0600 \text{ mol}
\]

\[
\text{total mol of KBr} = 0.0250 \text{ mol} + 0.0600 \text{ mol} = 0.0850 \text{ mol}
\]

\[
\text{Molarity of KBr} = \left(\frac{0.0850 \text{ mol}}{0.0500 \text{ L}}\right) = 1.70 \text{ M}
\]
5. Hard water contains Ca\(^{2+}\), Mg\(^{2+}\) and Fe\(^{2+}\), which interfere with the action of soap and leave an insoluble coating on the insides of containers and pipes when heated. Water softeners replace these ions with Na\(^{+}\). If \(1.0 \times 10^3\) L of hard water contains 0.010 M Ca\(^{2+}\) and 0.0050 M Mg\(^{2+}\), how many moles of Na\(^{+}\) are needed to replace these ions?

\[
\text{mol Ca}^{2+} = (1.0 \times 10^3 \text{ L}) \left( \frac{0.010 \text{ mol}}{1 \text{ L}} \right) = 10 \text{ mol}
\]

\[
\text{mol Mg}^{2+} = (1.0 \times 10^3 \text{ L}) \left( \frac{0.0050 \text{ mol}}{1 \text{ L}} \right) = 5.0 \text{ mol}
\]

Total mol of 2+ ions to replace = 15 mol

mol of Na\(^{+}\) (1+) needed to replace 2+ ions = 15 mol \times 2 = 30 mol

6. A mixture contains 89.0% NaCl, 1.5% MgCl\(_2\) and 8.5% Na\(_2\)SO\(_4\) by mass. What is the molarity of Cl\(^{-}\) ions in a solution formed by dissolving 7.50 g of the mixture in enough water to form 500.0 mL of solution?

mass NaCl in mixture = \((0.890)(7.50 \text{ g}) = 6.675 \text{ g}\)

mol NaCl in mixture = \((6.675 \text{ g}) \left( \frac{1 \text{ mol}}{58.4429 \text{ g}} \right) = 0.1142 \text{ mol}\)

mol Cl\(^{-}\) in mixture from NaCl = \((0.1142 \text{ mol NaCl}) \left( \frac{1 \text{ mol Cl}^{-}}{1 \text{ mol NaCl}} \right) = 0.1142 \text{ mol Cl}^{-}\)

mass MgCl\(_2\) in mixture = \((0.015)(7.50 \text{ g}) = 0.1125 \text{ g}\)

mol MgCl\(_2\) in mixture = \((0.1125 \text{ g}) \left( \frac{1 \text{ mol}}{95.211 \text{ g}} \right) = 0.0011816 \text{ mol}\)

mol Cl\(^{-}\) in mixture from MgCl\(_2\) = \((0.0011816 \text{ mol MgCl}_2) \left( \frac{2 \text{ mol Cl}^{-}}{1 \text{ mol MgCl}_2} \right) = 0.002363 \text{ mol Cl}^{-}\)

Total mol of Cl\(^{-}\) in mixture = 0.1142 mol + 0.002363 mol = 0.12 mol

Molarity of Cl\(^{-}\) = \(0.12 \text{ mol} / 0.5000 \text{ L} = 0.23 \text{ M}\)