1. How many moles of Ca(NO₃)₂ are contained in 150.0-mL of a 0.245-M solution of Ca(NO₃)₂?

\[ ? \text{ mol Ca(NO}_3\text{)}_2 = \frac{150.0\text{mL} \times 0.245\text{mol Ca(NO}_3\text{)}_2}{1000\text{mL}} = 0.03675 \text{mol Ca(NO}_3\text{)}_2 \]

2. How many grams of KCl are required to make 450.0-mL of a solution that is 0.100-M KCl?

\[ ? \text{ g KCl} = \frac{450.0\text{mL} \times 0.100\text{mol KCl}}{1000\text{mL}} \times \frac{74.5\text{KCl}}{1\text{mol KCl}} = 3.353 \text{g KCl} \]

3. 34.5-g of BaBr₂ are dissolved in water to make a solution that has a total volume of 750.0-mL. What is the molarity of BaBr₂, Ba²⁺, and Br⁻ in the solution?

\[ M = \frac{34.5\text{g BaBr}_2}{\frac{297 \text{g/mol}}{0.750\text{L}}} = 0.155 \text{M BaBr}_2 \]

*For the molarity of the other species, realize that each mol of BaBr₂ provides one mol of Ba²⁺ and 2 mol of Br⁻. Their concentrations are 1x0.155M = 0.155 M Ba²⁺ and 2 x 0.155 M = 0.310 M Br⁻.*

4. 0.415-g of potassium hydrogen phthalate are dissolved in water and phenolphthalein indicator added. The equivalence point is reached with the addition of 31.95-mL of a NaOH solution. What is the molarity of the NaOH solution? (Molar mass of KHP = 204.1 g/mol)

*Potassium hydrogen phthalate, KHC₈H₄O₄, reacts with NaOH according to the equation:*

\[ \text{KHC}_8\text{H}_4\text{O}_4\text{(aq) + NaOH (aq) } \rightarrow \text{ NaKC}_8\text{H}_4\text{O}_4\text{(aq) + HOH (R)} \]

*From the equation, note that one mole of KHC₈H₄O₄ reacts with 1 mol of NaOH. So, if we know how many mol of KHC₈H₄O₄ were in the flask initially, we can determine the number of moles of NaOH in the volume of NaOH delivered.*

\[ \# \text{mol KHC}_8\text{H}_4\text{O}_4 = \frac{0.415\text{g KHC}_8\text{H}_4\text{O}_4}{204.1\text{g/mol}} = 2.03 \times 10^{-3} \text{ mol KHC}_8\text{H}_4\text{O}_4 \]

\[ \text{so} \quad \# \text{mol NaOH} = 2.03 \times 10^{-3} \text{ mol NaOH} \]

\[ \text{so} \quad M_{\text{NaOH}} = \frac{\# \text{mol NaOH}}{\# \text{L NaOH}} = \frac{2.03 \times 10^{-3} \text{ mol NaOH}}{0.03195 \text{ L solution}} = 6.36 \times 10^{-2} \text{ M NaOH} \]
5. Find the oxidation number of the underlined element in each of the following species.

\[ \text{AsO}_4^{3-} \quad +5 \quad \text{Ba(NO}_2)_2 \quad +3 \quad \text{N}_2\text{O}_5 \quad +5 \]

\[ \text{NH}_4^+ \quad -3 \quad \text{HCO}_3^- \quad +4 \]

6. Complete and balance the following equations. Also write the total ionic and net ionic equations for each.

\[ 3 \text{SrCl}_2 (\text{aq}) + 2 \text{Na}_3\text{PO}_4 (\text{aq}) \longrightarrow \text{Sr}_3(\text{PO}_4)_2 (\text{s}) + 6 \text{NaCl (aq)} \]

Total Ionic:
\[ 3 \text{Sr}^{2+} (\text{aq}) + 6 \text{Cl}^- (\text{aq}) + 6 \text{Na}^+ (\text{aq}) + 2 \text{PO}_4^{3-} (\text{aq}) \quad \rightarrow \quad \text{Sr}_3(\text{PO}_4)_2 (\text{s}) + 6 \text{Na}^+ (\text{aq}) + 6 \text{Cl}^- (\text{aq}) \]

Net Ionic:
\[ 3 \text{Sr}^{2+} (\text{aq}) + 2 \text{PO}_4^{3-} (\text{aq}) \quad \rightarrow \quad \text{Sr}_3(\text{PO}_4)_2 (\text{s}) \]

\[ 3 \text{Li} (\text{s}) + \text{FeCl}_3 (\text{aq}) \longrightarrow 3 \text{LiCl} (\text{aq}) + \text{Fe} (\text{s}) \]

Total Ionic:
\[ 3 \text{Li} (\text{s}) + \text{Fe}^{3+} (\text{aq}) + 3 \text{Cl}^- (\text{aq}) \quad \rightarrow \quad 3 \text{Li}^+ (\text{aq}) + 3 \text{Cl}^- (\text{aq}) + \text{Fe} (\text{s}) \]

Net Ionic:
\[ 3 \text{Li} (\text{s}) + \text{Fe}^{3+} (\text{aq}) \quad \rightarrow \quad 3 \text{Li}^+ (\text{aq}) + \text{Fe} (\text{s}) \]

7. Classify each of the following as to whether it is a salt, acid, or base (S/A/B); soluble or insoluble (S/I); and strong or weak/non electrolyte (S/W).

<table>
<thead>
<tr>
<th>Compound</th>
<th>A/B/S</th>
<th>S/I</th>
<th>S/W</th>
<th>Compound</th>
<th>A/B/S</th>
<th>S/I</th>
<th>S/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>HNO\textsubscript{2}</td>
<td>A</td>
<td>S</td>
<td>W</td>
<td>PbBr\textsubscript{2}</td>
<td>S</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>BaSO\textsubscript{4}</td>
<td>S</td>
<td>I</td>
<td>S</td>
<td>Cu(NO\textsubscript{3})\textsubscript{2}</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>HCO\textsubscript{3}</td>
<td>A</td>
<td>S</td>
<td>W</td>
<td>Fe\textsubscript{2}O\textsubscript{3}</td>
<td>S</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>H\textsubscript{2}C\textsubscript{6}H\textsubscript{4}O\textsubscript{4}</td>
<td>A</td>
<td>S</td>
<td>W</td>
<td>(NH\textsubscript{4})\textsubscript{2}S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Fe(OH)\textsubscript{3}</td>
<td>B</td>
<td>I</td>
<td>S</td>
<td>H\textsubscript{2}S</td>
<td>A</td>
<td>S</td>
<td>W</td>
</tr>
</tbody>
</table>
8. Complete the following metathesis reaction and write the total ionic equation and the net ionic equation.

Molecular equation:
\[ \text{CaCl}_2 \ (aq) + \text{Pb(NO}_3\text{)}_2 \ (aq) \rightarrow \text{Ca(NO}_3\text{)}_2 \ (aq) + \text{PbCl}_2 \ (s) \]

Total Ionic:
\[ \text{Ca}^{2+} \ (aq) + 2 \text{Cl}^{-} \ (aq) + \text{Pb}^{2+} \ (aq) + 2 \text{NO}_3^- \ (aq) \rightarrow \text{Ca}^{2+} \ (aq) + 2 \text{NO}_3^- \ (aq) + \text{PbCl}_2 \ (s) \]

Net Ionic:
\[ 2 \text{Cl}^{-} \ (aq) + \text{Pb}^{2+} \ (aq) \rightarrow \text{PbCl}_2 \ (s) \]

9. Complete and balance the following metathesis reactions. Further write the total ionic and net ionic equations for each:

\[ \text{3 BaCl}_2 \ (aq) + 2 \text{Na}_3\text{PO}_4 \ (aq) \rightarrow \text{Ba}_3\text{(PO}_4\text{)}_2 \ (s) + 6 \text{NaCl} \ (aq) \]

Total Ionic:
\[ 3 \text{Ba}^{2+} \ (aq) + 6 \text{Cl}^{-} \ (aq) + 6 \text{Na}^+ \ (aq) + 2 \text{PO}_4^{3-} \ (aq) \rightarrow \text{Ba}_3\text{(PO}_4\text{)}_2 \ (s) + 6 \text{Na}^+ \ (aq) + 6 \text{Cl}^{-} \ (aq) \]

Net Ionic:
\[ 3 \text{Ba}^{2+} \ (aq) + 2 \text{PO}_4^{3-} \ (aq) \rightarrow \text{Ba}_3\text{(PO}_4\text{)}_2 \ (s) \]

\[ \text{HC}_2\text{H}_3\text{O}_2 \ (aq) + \text{KOH} \ (aq) \rightarrow \text{HOH} \ (R) + \text{K}^+ \ (aq) + \text{C}_2\text{H}_3\text{O}_2^- \ (aq) \]

Total Ionic:
\[ \text{HC}_2\text{H}_3\text{O}_2 \ (aq) + \text{K}^+ \ (aq) + \text{OH}^- \ (aq) \rightarrow \text{HOH} \ (R) + \text{K}^+ \ (aq) + \text{C}_2\text{H}_3\text{O}_2^- \ (aq) \]

Net Ionic:
\[ \text{HC}_2\text{H}_3\text{O}_2 \ (aq) + \text{OH}^- \ (aq) \rightarrow \text{HOH} \ (R) + \text{C}_2\text{H}_3\text{O}_2^- \ (aq) \]

10. Classify each of the following solutes as acids, bases, or salts. For each indicate whether it is a strong or weak/non electrolyte (SE or WE) and whether the substance is soluble (S) or insoluble (I) in aqueous solution.

H$_2$SO$_3$  **Acid, weak, soluble**

Ba$_3$(PO$_4$)$_2$  **Salt, Strong, Insoluble**

NaCl  **Salt, Strong, Soluble**

NH$_4$Cl  **Salt, Strong, Soluble**

BaBr$_2$  **Salt, Strong, Soluble**
11. For each of the following:
   a. State whether it is an acid (A), base (B), or salt (S).
   b. State whether it is a strong electrolyte (SE) or weak/nonelectrolyte (WE).
   c. State whether it is soluble (S) or insoluble (I).

<table>
<thead>
<tr>
<th>Substance</th>
<th>Acid(A)/Base(B)/Salt(S)</th>
<th>Strong Electrolyte (SE)/Weak Electrolyte (WE)</th>
<th>Soluble (S)/Insoluble (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCl</td>
<td>S</td>
<td>SE</td>
<td>S</td>
</tr>
<tr>
<td>(NH₄)₂S</td>
<td>S</td>
<td>SE</td>
<td>S</td>
</tr>
<tr>
<td>HNO₂</td>
<td>A</td>
<td>WE</td>
<td>S</td>
</tr>
<tr>
<td>PbCl₂</td>
<td>S</td>
<td>SE</td>
<td>I</td>
</tr>
<tr>
<td>Fe(OH)₃</td>
<td>B</td>
<td>SE</td>
<td>I</td>
</tr>
<tr>
<td>Ba₃(PO₄)₂</td>
<td>S</td>
<td>SE</td>
<td>I</td>
</tr>
<tr>
<td>HClO₄</td>
<td>A</td>
<td>SE</td>
<td>S</td>
</tr>
<tr>
<td>HBrO</td>
<td>A</td>
<td>WE</td>
<td>S</td>
</tr>
<tr>
<td>Ba(C₂H₃O₂)₂</td>
<td>S</td>
<td>SE</td>
<td>S</td>
</tr>
<tr>
<td>Mg(OH)₂</td>
<td>B</td>
<td>SE</td>
<td>I</td>
</tr>
</tbody>
</table>

12. Classify each of the following reactions as to whether it is combustion, decomposition, combination, metathesis, or oxidation-reduction. Note some equations may fall into more than one category. State all categories that apply in each case.

<table>
<thead>
<tr>
<th>Equation</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 NaHCO₃ (s) ----&gt; Na₂CO₃ (s) + H₂O (R) + CO₂ (g)</td>
<td>decomposition</td>
</tr>
<tr>
<td>BaO (s) + H₂O (R) ----&gt; Ba(OH)₂ (aq)</td>
<td>combination</td>
</tr>
<tr>
<td>Ba(NO₃)₂ (aq) + Na₂SO₄ (aq) ----&gt; BaSO₄ (s) + 2 NaNO₃ (aq)</td>
<td>metathesis</td>
</tr>
<tr>
<td>Cu (s) + 2 AgNO₃ (aq) ----&gt; 2 Ag (s) + Cu(NO₃)₂ (aq)</td>
<td>oxidation-reduction</td>
</tr>
<tr>
<td>CH₄ (g) + 2 O₂ (g) → CO₂ (g) + 2 H₂O (R)</td>
<td>combustion, oxidation-reduction</td>
</tr>
</tbody>
</table>
13. Complete and balance each of the methathesis equations below and write the total ionic and net ionic equation for each.

\[ \text{H}_2\text{SO}_4 (aq) + 2 \text{ NaOH (aq)} \rightarrow \]

**Complete equation:** \[ \text{H}_2\text{SO}_4 (aq) + 2 \text{ NaOH (aq)} \rightarrow \text{HOH (ℓ)} + \text{Na}_2\text{SO}_4 (aq) \]

**Total ionic equation:**
\[ 2 \text{H}^+ (aq) + \text{SO}_4^{2-} (aq) + 2 \text{Na}^+ (aq) + 2 \text{OH}^- (aq) \rightarrow \text{HOH (ℓ)} + 2 \text{Na}^+ (aq) + \text{SO}_4^{2-} (aq) \]

**Net ionic equation:**
\[ 2 \text{H}^+ (aq) + 2 \text{OH}^- (aq) \rightarrow \text{HOH (ℓ)} \]

\[ \text{BaCl}_2 (aq) + \text{Pb(NO}_3\text{)}_2 \rightarrow \]

**Complete equation:** \[ \text{BaCl}_2 (aq) + \text{Pb(NO}_3\text{)}_2 \rightarrow \text{Ba(NO}_3\text{)}_2 (aq) + \text{PbCl}_2 (s) \]

**Total ionic equation:**
\[ \text{Ba}^{2+} (aq) + 2 \text{Cl}^- (aq) + \text{Pb}^{2+} (aq) + 2 \text{NO}_3^- (aq) \rightarrow \text{Ba}^{2+} (aq) + 2 \text{NO}_3^- (aq) + \text{PbCl}_2 (s) \]

**Net ionic equation:**
\[ 2 \text{Cl}^- (aq) + \text{Pb}^{2+} (aq) \rightarrow \text{PbCl}_2 (s) \]

14. a. In the standardization reaction of a solution of NaOH, 0.4529-g of potassium hydrogen phthalate (molar mass = 204.2) is weighed into an Erlenmeyer flask. Water and phenolphthalein are added to the flask to dissolve the phthalate and provide an indicator for the titration. 34.75-mL of the NaOH solution were required to reach the endpoint in the titration between the potassium hydrogen phthalate and the NaOH. What is the molarity of the NaOH solution?

\[ \# \text{molKHP} = \frac{0.4529 \text{gKHP}}{204.2 \text{g}} = 0.002218 \text{molKHP} \]

\[ \# \text{molKHP} = \# \text{molNaOH} = 0.002218 \text{molNaOH} \]

\[ M_{\text{NaOH}} = \frac{0.002218 \text{molNaOH}}{0.03475 \text{L}} = 0.06383 \text{MNaOH} \]

b. The same NaOH solution from part a is used to titrate 25.00-mL of a H\textsubscript{2}SO\textsubscript{4} solution. The titration requires 29.45-mL of the NaOH solution. What is the molarity of the H\textsubscript{2}SO\textsubscript{4}? 

\[ \# \text{molNaOH} = 0.02945 \text{LNaOHSolution} \times 0.06383 \text{MNaOH} = 0.001880 \text{molNaOH} \]

\[ \# \text{molH}_2\text{SO}_4 = \frac{1}{2} \times \# \text{molNaOH} = 0.0009399 \]

\[ M_{\text{H}_2\text{SO}_4} = \frac{0.0009399 \text{molH}_2\text{SO}_4}{0.025 \text{Lsolution}} = 0.03760 \text{M} \]
15. Indicate for each of the following aqueous solutions whether there would be a precipitate formed upon mixing or not. If a precipitate is formed indicate the formula and name for the precipitate. (Hint: Think metathesis)

a. Pb(NO$_3$)$_2$ and KCl  **Yes; PbCl$_2$; lead (II) chloride**

b. BaBr$_2$ and NH$_4$NO$_3$  **No; both Ba(NO$_3$)$_2$ and NH$_4$Br are soluble**

c. AgNO$_3$ and CaCl$_2$  **Yes; AgCl; silver chloride**

d. BaCl$_2$ QH$_2$O and Na$_3$PO$_4$ Q2 H$_2$O  **Yes; Ba$_3$(PO$_4$)$_2$; barium phosphate**

e. KBr and NaCl  **No; both KCl and NaBr are soluble**

16. For one of the reactions that forms a precipitate in question 15:

a. Write the balanced chemical equation.

b. Write the total ionic equation.

c. Write the net ionic equation.

**For reaction a of problem 15:**

*Total molecular equation:*  
$$\text{Pb(NO}_3\text{)}_2 (aq) + 2 \text{KCl (aq)} \rightarrow \text{PbCl}_2 (s) + 2 \text{KNO}_3 (aq)$$

*Total ionic equation:*  
$$\text{Pb}^{2+} (aq) + 2 \text{NO}_3^- (aq) + 2 \text{K}^+ (aq) + 2 \text{Cl}^- (aq) \rightarrow \text{PbCl}_2 (s) + 2 \text{K}^+ (aq) + 2 \text{NO}_3^- (aq)$$

*Net ionic equation:*  
$$\text{Pb}^{2+} (aq) + 2 \text{Cl}^- (aq) \rightarrow \text{PbCl}_2 (s)$$

17. Balance each of the following equations and classify it as combustion, decomposition, combination, metathesis, and/or oxidation-reduction. Note that some equations may fall into more than one category. State all categories that apply in each case.

<table>
<thead>
<tr>
<th>Equation</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2 \text{C(gr)} + ___ \text{O}_2 (g) \rightarrow 2 \text{CO} (g)$</td>
<td>combustion and redox</td>
</tr>
<tr>
<td>___ \text{NH}_3 (g) + ___ \text{HCl (g)} \rightarrow ___ \text{NH}_4\text{Cl (s)}</td>
<td>combination</td>
</tr>
<tr>
<td>___ \text{Cr(s)} + ___ \text{NiSO}_4 (aq) \rightarrow ___ \text{Ni} (s) + ___ \text{CrSO}_4 (aq)</td>
<td>redox</td>
</tr>
<tr>
<td>___ \text{HC}_2\text{H}_3\text{O}_2 (aq) + ___ \text{NaOH(aq)} \rightarrow ___ \text{HOH} (\text{R}) + ___ \text{NaC}_2\text{H}_3\text{O}_2 (aq)</td>
<td>metathesis</td>
</tr>
<tr>
<td>$2 \text{H}_2\text{O} (\text{R}) \rightarrow 2 \text{H}_2 (g) + ___ \text{O}_2 (g)$</td>
<td>decomposition/redox</td>
</tr>
</tbody>
</table>

18. Classify each of the following as an acid (A), base (B), or salt (S). Further classify each as to whether it is a strong electrolyte (SE) or weak/non electrolyte (WE).

<table>
<thead>
<tr>
<th>Substance</th>
<th>Type</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBr</td>
<td>Acid</td>
<td>SE</td>
</tr>
<tr>
<td>BaSO$_4$</td>
<td>Salt</td>
<td>SE</td>
</tr>
<tr>
<td>NaOH</td>
<td>Base</td>
<td>SE</td>
</tr>
<tr>
<td>NH$_4$Cl</td>
<td>Salt</td>
<td>SE</td>
</tr>
<tr>
<td>AgCl</td>
<td>Salt</td>
<td>SE</td>
</tr>
<tr>
<td>Cu(OH)$_2$</td>
<td>Base</td>
<td>SE</td>
</tr>
<tr>
<td>Mn(NO$_3$)$_2$</td>
<td></td>
<td>SE</td>
</tr>
<tr>
<td>K$_2$C$_2$O$_4$</td>
<td></td>
<td>SE</td>
</tr>
<tr>
<td>NaF</td>
<td>Salt</td>
<td>SE</td>
</tr>
<tr>
<td>BaBr$_2$</td>
<td>Salt</td>
<td>SE</td>
</tr>
</tbody>
</table>
19. Complete and balance each of the following metathesis reactions. Further write the total ionic and net ionic equation for each.

a. Molecular: $\text{Ba(NO}_3\text{)}_2$ (aq) + $\text{Na}_2\text{SO}_4$ (aq) $\rightarrow$ $\text{BaSO}_4$ (s) + $2\text{NaNO}_3$ (aq)

Total Ionic: $\text{Ba}^{2+}$ (aq) + $2\text{NO}_3^-$ (aq) + $2\text{Na}^+$ (aq) + $\text{SO}_4^{2-}$ (aq) $\rightarrow$ $\text{BaSO}_4$ (s) + $2\text{Na}^+$ (aq) + $2\text{NO}_3^-$ (aq)

Net Ionic: $\text{Ba}^{2+}$ (aq) + $\text{SO}_4^{2-}$ (aq) $\rightarrow$ $\text{BaSO}_4$ (s)

b. Molecular: $\text{2HCl}$ (aq) + $\text{Ba(OH)}_2$ (aq) $\rightarrow$ $2\text{HOH}$ (ℓ) + $\text{BaCl}_2$ (aq)

Total Ionic: $2\text{H}^+$ (aq) + $2\text{Cl}^-$ (aq) + $\text{Ba}^{2+}$ (aq) + $2\text{OH}^-$ (aq) $\rightarrow$ $2\text{HOH}$ (ℓ) + $\text{Ba}^{2+}$ (aq) + $2\text{Cl}^-$ (aq)

Net Ionic: $2\text{H}^+$ (aq) + $2\text{OH}^-$ (aq) $\rightarrow$ $2\text{HOH}$ (ℓ)

Or $\text{H}^+$ (aq) + $\text{OH}^-$ (aq) $\rightarrow$ $\text{HOH}$ (ℓ)

20. 30.00-mL of a 0.130-M solution of $\text{AgNO}_3$ is mixed with 20.00-mL of a 0.120-M solution of $\text{BaCl}_2$. How many grams of $\text{AgCl}$ could be formed in this process?

Since we are given amounts of two reactants, we need to figure out which one is the limiting reactant. The problem involves determining which reactant will be used up. The determination of the limiting reactant requires determining how many moles of each reactant are present in the mixture. This is done by multiplying the number of liters by the molarity of the respective solution.

$\#\text{molAgNO}_3 = 0.0300 L \times 0.130 M = 0.003900 \text{molAgNO}_3$

$\#\text{molBaCl}_2 = 0.0200 L \times 0.120 M = 0.002400 \text{molBaCl}_2$

$0.003900 \text{ mol AgNO}_3 \quad 0.002400 \text{ mol BaCl}_2$

$2 \text{ mol AgNO}_3 + 1 \text{ mol BaCl}_2 \rightarrow 2 \text{ mol AgCl} + 1 \text{ mol Ba(NO}_3\text{)}_2$

To check for limiting reactant, compare the two ratios:

$\frac{0.003900 \text{ mol AgNO}_3}{2 \text{ mol AgNO}_3} = 0.001950 \quad \frac{0.002400 \text{ mol BaCl}_2}{1 \text{ mol BaCl}_2} = 0.002400$

Since the $\text{AgNO}_3$ ratio is lower, it is the limiting reactant. To find the grams of $\text{AgCl}$, use the $\text{AgNO}_3$ since it is limiting.

$\#\text{gAgCl} = \frac{0.003900 \text{ mol AgNO}_3}{2 \text{ mol AgNO}_3} \times \frac{2 \times 142.5 \text{ g AgCl}}{1}$

$= 0.5558 \text{ g AgCl}$
21. Identify each of the following as an acid, base, or salt. Further identify each as a strong electrolyte (SE) or weak/non electrolyte (WE).

\[ \text{Ba(NO}_3\text{)}_2 \quad \text{Salt,SE} \quad \text{HF} \quad \text{Acid,WE} \]

\[ \text{LiOH} \quad \text{Base,SE} \quad \text{Ca(C}_2\text{H}_3\text{O}_2\text{)}_2 \quad \text{Salt,SE} \]

\[ \text{HNO}_2 \quad \text{Acid,WE} \]

22. Label each of the following as an acid, base, or salt. Further identify each as a strong electrolyte (SE), or a weak/non electrolyte (WE).

\[ \text{Ba(NO}_3\text{)}_2 \quad \text{Salt;SE} \quad \text{CaBr}_2 \quad \text{Salt;SE} \]

\[ \text{HC}_2\text{H}_3\text{O}_2 \quad \text{Acid;WE} \quad \text{HF} \quad \text{Acid;WE} \]

\[ \text{LiOH} \quad \text{Base;SE} \quad \text{HOH} \quad \text{A/B;WE} \]

\[ \text{HNO}_2 \quad \text{Acid;WE} \quad \text{Cu(OH)}_2 \quad \text{Base;SE} \]

\[ \text{RbC}_8\text{H}_14\text{O}_2 \quad \text{Salt;SE} \quad \text{Ba}_3\text{(PO}_4\text{)}_2 \quad \text{Salt;SE} \]

23. 25.00-mL of 0.10 M HCl are mixed with 35.00 mL of 0.15 M Pb(NO\(_3\))\(_2\).

a. Write a balanced chemical equation for this metathesis reaction.

\[
2 \text{HCl (aq)} + \text{Pb(NO}_3\text{)}_2 \text{(aq)} \rightarrow 2 \text{HNO}_3 \text{(aq)} + \text{PbCl}_2 \text{(s)}
\]

b. Which is the limiting reactant?

**Check number of moles of each:**

\[
\# \text{mol HCl} = 0.025L \times 0.20 \text{ M HCl} = 0.0050 \text{ mol HCl}
\]

\[
\# \text{mol Pb(NO}_3\text{)}_2 = 0.035 L \times 0.15 \text{ M Pb(NO}_3\text{)}_2 = 0.00525 \text{ mol Pb(NO}_3\text{)}_2
\]

Need twice as many mol of HCl as Pb(NO\(_3\))\(_2\), meaning we would need 2 x 0.00525 mol Pb(NO\(_3\))\(_2\) which is 0.01050 mol of the HCl. There is not enough. HCl is limiting.

c. How many grams of PbCl\(_2\) could be formed in the reaction?

**Use the HCl since it is limiting.**

\[
\# \text{mol PbCl}_2 = \frac{0.0050 \text{ mol HCl}}{1} \times \frac{1 \times 278 \text{ g PbCl}_2}{2 \text{ mol HCl}} = 0.695 \text{ g PbCl}_2
\]
24. Balance each of the following equations. Also classify each as to whether it is combination, decomposition, single displacement, metathesis, or redox. Some equations may fall into more than one category. Be sure to list all categories that apply for each equation.

**Classification(s)**

\[ 2 \text{SO}_3 (g) \rightarrow 6 \text{SO}_2 (g) + ____ \text{O}_2 (g) \]  
*decomposition, redox*

\[ ____ \text{BI}_3 + ____ \text{GaF}_3 \rightarrow 6 ____ \text{BF}_3 + ____ \text{GaI}_3 \]  
*metathesis*

\[ ____ \text{P}_4 + 5 \text{O}_2 \rightarrow 6 ____ \text{P}_4\text{O}_{10} \]  
*combination, redox*

\[ 2 \text{C}_4\text{H}_{10} + 13 \text{O}_2 \rightarrow 6 8 \text{CO}_2 + 10 \text{H}_2\text{O} \]  
*combustion, redox*

\[ ____ \text{Zn} + 2 \text{HCl} \rightarrow 6 ____ \text{ZnCl}_2 + ____ \text{H}_2 \]  
*displacement, redox*

25. Complete and balance the following metathesis reactions. Further write the total ionic and net ionic equation for each.

**Total Ionic:**

\[ \text{BaCO}_3 (s) \rightarrow 2 \text{HNO}_3 (aq) \rightarrow 6 \text{Ba(NO}_3)_2 (aq) + \text{H}_2\text{CO}_3 (aq) \]

**Net Ionic:**

\[ \text{BaCO}_3 (s) + 2 \text{H}^+ (aq) + 2 \text{NO}_3^- (aq) \rightarrow \text{Ba}^{2+} (aq) + 2 \text{NO}_3^- (aq) + \text{H}_2\text{CO}_3 (aq) \]

(Note: In water, the \( \text{H}_2\text{CO}_3 \) breaks into water and carbon dioxide – you would see bubbles coming off)

**Total Ionic:**

\[ \text{H}_2\text{SO}_4 (aq) \rightarrow 2 \text{NaOH} (aq) \rightarrow 6 \text{Na}_2\text{SO}_4 (aq) + 2 \text{HOH} (l) \]

**Net Ionic:**

\[ 2 \text{H}^+ (aq) + 2 \text{OH}^- (aq) \rightarrow 2 \text{HOH} (l) \]

Or

\[ \text{H}^+ (aq) + \text{OH}^- (aq) \rightarrow \text{HOH} (l) \]
26. 125.0-mL of 0.183 M HNO₃ is diluted with water to 500.0-mL in a volumetric flask. What is the new concentration of the HNO₃?

\[ M_1V_1 = M_2V_2 \]

\[ 0.183M \times 125.0mL = M_2 \times 500.0mL \]

\[ M_2 = \frac{0.183M \times 125.0mL}{500.0mL} = 0.458M \]