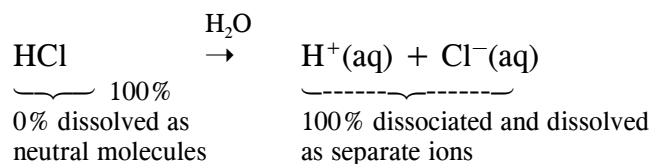
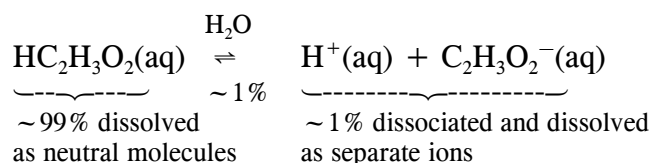


Appendix B

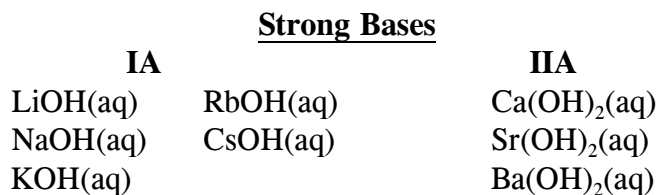
Net Ionic Equations



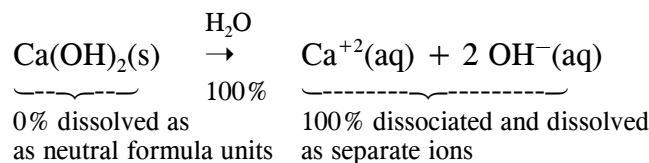
e.g., $\text{HC}_2\text{H}_3\text{O}_2$, H_2CO_3 , HF , H_2S , etc., is a *weak acid* and therefore a *weak electrolyte*. Weak electrolytes dissolve but dissociate less than 100% to form ions. Thus, an aqueous solution of a weak electrolyte contains a relatively low concentration of ions. For example, the weak acid acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$, readily dissolves in water. However, the majority of this acid (~99%) dissolves as neutral molecules of $\text{HC}_2\text{H}_3\text{O}_2$. Only a small amount (~1%) dissociates and exists as separate ions of $\text{H}^+(\text{aq})$ and $\text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$. The dissolution equation for $\text{HC}_2\text{H}_3\text{O}_2$ is represented as shown below.



Most general chemistry books agree that the Group IA metal hydroxides and the heavier Group IIA metal hydroxides given below are strong bases (ergo strong electrolytes) when dissolved in water. Consequently, an aqueous solution of the strong base calcium hydroxide,



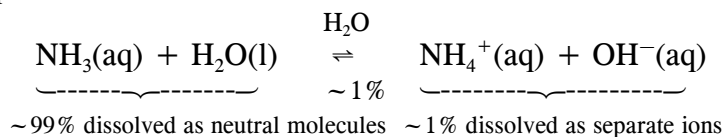
$\text{Ca(OH)}_2(\text{aq})$, really consists of dissociated and separated ions of $\text{Ca}^{+2}(\text{aq})$ and $\text{OH}^-(\text{aq})$. Neutral formula units of Ca(OH)_2 do not exist dissolved in solution. However, if the solution is saturated with Ca^{+2} and OH^- ions, solid undissolved Ca(OH)_2 may be present as a precipitate at the bottom of the vessel. The dissolution equation for Ca(OH)_2 is represented as shown below. When dissolved in water, *weak bases*, such as ammonia and its derivatives, are classified as



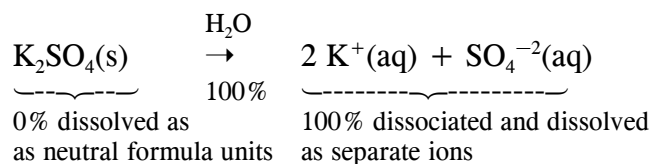
weak electrolytes. For example, the weak base ammonia, NH_3 , readily dissolves in water. However, the majority of this base (~99%) dissolves as neutral molecules of NH_3 . A small amount (~1%) reacts with water to form separated ions of $\text{NH}_4^+(\text{aq})$ and $\text{OH}^-(\text{aq})$, as shown

Appendix B Net Ionic Equations

below in the dissolution equation.



Soluble ionic compounds are also classified as strong electrolytes when dissolved in water. The solubility rules, given in Appendix C, are used to determine whether an ionic compound is soluble (ergo a strong electrolyte) or insoluble (ergo not a strong electrolyte). For example, consider the two ionic compounds, K_2SO_4 and BaSO_4 . The fourth solubility rule specifies that K_2SO_4 is soluble; whereas BaSO_4 is insoluble. Therefore, of the two sulfates, only the K_2SO_4 is a strong electrolyte. Consequently, an aqueous solution of potassium sulfate, $\text{K}_2\text{SO}_4(\text{aq})$, really consists of dissociated and separated ions of $\text{K}^+(\text{aq})$ and $\text{SO}_4^{-2}(\text{aq})$. Neutral formula units of K_2SO_4 do not exist dissolved in solution. However, if the solution is saturated with K^+ and SO_4^{-2} ions, solid undissolved K_2SO_4 may be present as a precipitate at the bottom of the vessel. The dissolution equation for K_2SO_4 is represented as shown below. Conversely, the insoluble BaSO_4 does not dissolve to any significant extent and will remain as a precipitate at the bottom of the vessel.¹



Net Ionic Equations

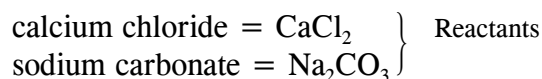
For chemical reactions taking place in aqueous solution, three different balanced equations can be written, the *molecular equation*, the *full ionic equation*, and the *net ionic equation*. The molecular equation includes full chemical formulas for all reactants and products. The full ionic equation shows all reactants and products as they actually exist in solution, i.e., strong electrolytes are shown dissociated into ions. The net ionic equation includes only the reacting species, i.e., ions or compounds that change in some way during the course of the reaction. Systematic and correct writing of the three equations in the order molecular, full ionic, and net ionic will result in correct derivation of the net ionic equation. This process is outlined in the following two examples.

¹The small amount of an insoluble ionic compound that does dissolve is dissociated 100% into ions. For example, insoluble BaSO_4 has a molar solubility of 1×10^{-5} M. This small amount of BaSO_4 that dissolves, dissociates 100% to give relatively low Ba^{+2} and SO_4^{-2} concentrations of 1×10^{-5} M.

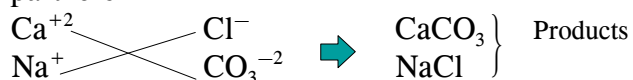
Appendix B Net Ionic Equations

EXAMPLE: Aqueous solutions of calcium chloride and sodium carbonate are mixed. Write the net ionic equation.

- Step 1:** A. Write correct chemical formulas for each compound given.



- B. If not given, predict products by allowing reactants to trade partners.



- C. Write the balanced molecular equation.

Balanced Molecular Equation:

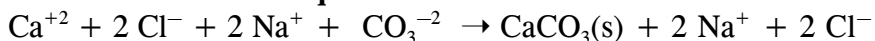


- Step 2:** A. Identify strong electrolytes. Remember.....strong electrolytes are strong acids, strong bases, and soluble ionic compounds. Use **Appendix C** to determine whether an ionic compound is soluble or insoluble.

CaCl₂: ionic compound → soluble by Rule #3 → **strong electrolyte**
Na₂CO₃: ionic compound → soluble by Rule #1 → **strong electrolyte**
CaCO₃: ionic compound → insoluble by Rule #6 → **precipitates**
NaCl: ionic compound → soluble by Rule #1 → **strong electrolyte**

- B. Write the full ionic equation by showing all species as they really exist in solution, i.e., strong electrolytes are shown dissociated into ions.

Balanced Full Ionic Equation:



- Step 3:** A. Identify *spectator ions*. Spectator ions are ions that appear on both sides of the equation in exactly the same form.

Spectator Ions: Na⁺ and Cl⁻
 These ions are present on both sides of the equation in the same form (dissolved in solution) and with the same charge.

Appendix B

Net Ionic Equations

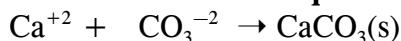
Reacting Ions:



These ions are changing form. On the reactant side they are dissolved in solution; whereas, on the product side they are present in an insoluble precipitate.

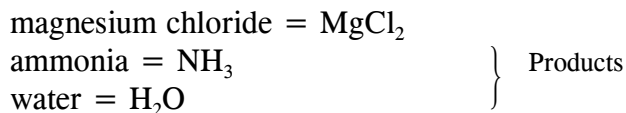
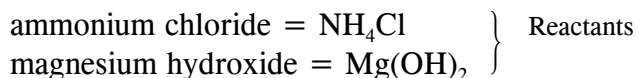
- B. Write the net ionic equation by removing spectator ions from the full ionic equation and balance (if the molecular equation was not previously balanced in Step 1C).

Balanced Net Ionic Equation:



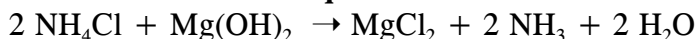
EXAMPLE: Aqueous solutions of ammonium chloride and magnesium hydroxide are mixed. Write the net ionic equation if the products of this reaction are magnesium chloride, ammonia, and water.

- Step 1:** A. Write correct chemical formulas for each compound given.



- B. Write the balanced molecular equation

Balanced Molecular Equation:



- Step 2:** A. Identify strong electrolytes.

NH₄Cl: ionic compound → soluble by Rule #1 → **strong electrolyte**

Mg(OH)₂: ionic compound → insoluble by Rule #6 → **solid**

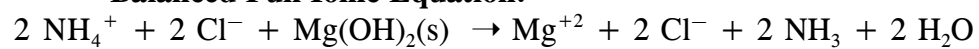
MgCl₂: ionic compound → soluble by Rule #3 → **strong electrolyte**

NH₃: molecular compound → weak base → **weak electrolyte**

H₂O: molecular compound → **weak or non-electrolyte**

- B. Write the full ionic equation by showing all species as they really exist in solution, i.e., strong electrolytes are shown dissociated into ions.

Balanced Full Ionic Equation:



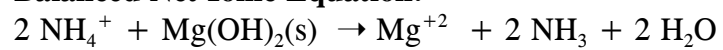
Step 3:

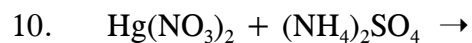
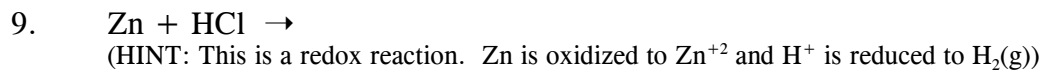
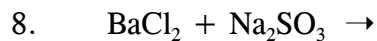
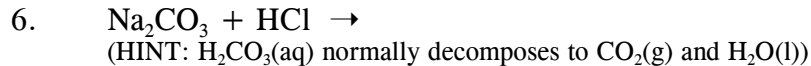
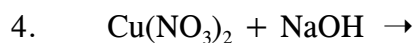
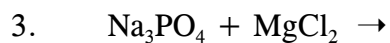
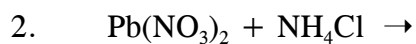
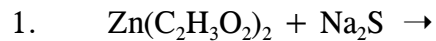
A. Identify *spectator ions*.

Spectator Ion: Cl^-

B. Write the net ionic equation by removing spectator ions.

Balanced Net Ionic Equation:



Appendix B Net Ionic Equations**Name:** _____**Questions:** Predict products and write the balanced net ionic equation for each of the following reactions. (Note: BaSO₃ is insoluble.)

Appendix B Net Ionic Equations

Questions: Write the balanced net ionic equation for each of the following reactions.

1. barium acetate + ammonium sulfate →
2. calcium hydroxide + sodium carbonate →
3. iron(III) nitrate + barium hydroxide →
4. barium hydroxide + hydrochloric acid →
5. silver nitrate + magnesium bromide →
6. acetic acid + potassium hydroxide →
7. sodium chromate + silver nitrate →
8. calcium chlorate + sodium phosphate →
9. ammonium chloride + sodium hydroxide →
(HINT: $\text{NH}_4\text{OH}(\text{aq})$ does not exist and decomposes to $\text{NH}_3(\text{g or aq})$ and $\text{H}_2\text{O}(\text{l})$)
10. calcium carbonate + sulfuric acid →
(HINT: $\text{H}_2\text{CO}_3(\text{aq})$ normally decomposes to $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$)