4.1. Distinguish between electrolytes and nonelectrolytes and write dissolution equations to predict the ions in solution. [Readings 4.1 Problems 4.1, 9, 25, & 26]

Electrolytes and Nonelectrolytes

- Solutes which yield electrically conducting solutions are called electrolytes.
- Dissociation - ionic compounds dissolve in water to yield separate ions in solution.
- Strong electrolyte - when dissociation is complete.
- Weak electrolyte - a significant amount of non-dissociated compound is present.
- Nonelectrolyte - don’t conduct electricity.

Conductivity Tester

Apparatus consists of 25 watt and 100 watt light bulbs wired in parallel in 120 volt AC circuit with two open leads inserted into test solution. Strong electrolytes light both bulb, weak electrolytes only the 25 watt bulb and nonelectrolyte neither.
Solutions of Electrolytes & Nonelectrolytes

Dissociation of an ionic compound as it dissolves in water. Hydrated ions more freely in solution making solution able to conduct electricity.

Molecular compounds dissolve in water as intact molecules. Solutions of molecular compounds are nonelectrolytes which can't conduct electricity.

Testing Conductivity of Aqueous Solutions

Animation of Cond. Tester electrolyte

Dissociation Equations

- Equations show solid phase and dissolved phase.
- KBr (s) → K⁺ (aq) + Br⁻(aq)
- Na₂CO₃ → 2 Na⁺ + CO₃²⁻ — Assumed to be aqueous
Practice

• Write the dissociation equations for the dissolving of the following salts.
  • MgCl$_2$
  • Calcium phosphate
  • Sodium hypochlorite

Weak vs. Strong Electrolytes

• Strong electrolytes dissociate 100%
  – HCl → H$^+$ + OH$^-$
• Weak electrolytes do not dissociate 100%
  – CH$_3$CO$_2$H + H$_2$O ⇔ H$_3$O$^+$ + CH$_3$CO$_2$–
  – Weak electrolytes are in equilibrium
  – The forward and the reverse reaction occur simultaneously

4.2. Write the complete reaction equation, the ionic equation, and the net ionic equation for solution reactions. [Readings 4.2 Problems 27, 29, 31, & 32]
Practice with the concept

• Sodium sulfite reacts with barium nitrate to produce solid barium sulfite.
• Write the molecular equation for the reaction.

Practice with the concept

• Sodium sulfite reacts with barium nitrate to produce solid barium sulfite.
• Write the ionic equation for the reaction.

Practice with the concept

• Sodium sulfite reacts with barium nitrate to produce solid barium sulfite.
• Write the net ionic equation for the reaction.
Practice with the concept

• Sodium sulfite reacts with barium nitrate to produce solid barium sulfite.
• Write the ionic equation for the reaction.
  \[ 2Na^+ + SO_3^{2-} + Ba^{2+} + 2NO_3^- \rightarrow BaSO_3(s) + 2Na^+ + 2NO_3^- \]
• The state is assumed to be aqueous except barium sulfite.

Balanced Ionic Equations

• All atoms must balance as in other reactions
• The net electrical charge must be the same on both sides of the arrow. The charge will not necessarily equal zero.

• Pb^{2+} + I^- \rightarrow PbI_2

• Not balanced for atoms or charge.

4.3. Use the solubility rules in Table 4.1 to predict the product of a precipitation reaction.
[Readings 4.3 & 4.8 Problems 47, 49, 51, 53, & 55]
### Solubility Rules

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All group 1A and ammonium salts are soluble.</td>
</tr>
<tr>
<td>2.</td>
<td>All salts containing the anions, NO$_3^-$, ClO$_4^-$, ClO$_3^-$, and CH$_3$CO$_2^-$ are soluble.</td>
</tr>
<tr>
<td>3.</td>
<td>All chloride, bromide, and iodide except when combined with Ag$^+$, Pb$^{2+}$, and Hg$_2^{2+}$.</td>
</tr>
<tr>
<td>4.</td>
<td>All SO$_4^{2-}$ are soluble except those containing Pb$^{2+}$, Ca$^{2+}$, Sr$^{2+}$, Br$^{2+}$, and Hg$_2^{2+}$.</td>
</tr>
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### Solubility Rules

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<tr>
<td>5.</td>
<td>All hydroxides, OH$^-$, and oxide (O$^2-$) are insoluble except those containing group 1A metals, Ca$^{2+}$, Sr$^{2+}$, Ba$^{2+}$.</td>
</tr>
<tr>
<td>6.</td>
<td>All PO$_4^{3-}$, CO$_3^{2-}$, SO$_3^{2-}$, and all S$^{2-}$ are insoluble.</td>
</tr>
</tbody>
</table>

### Predicting Precipitation reactions

- Write the ionic and net ionic equation for the reaction of lead nitrate and sodium chloride.
- What species would be the precipitate?
Practice with the concept

- Predict which of the following combinations would produce a precipitate and name the precipitate.
  - Mixing NaCl with Ba(NO$_3$)$_2$
  - Mixing lead acetate with sodium bromide
  - Calcium chloride with sodium sulfide
  - Potassium nitrate with ammonium carbonate

4.4. Classify acids and bases and explain their behavior using the Arrhenius definition of acids and bases. [Readings 4.4-4.5 Problems 13, 14, 16, 17, & list the 4 strong bases]

Defining acids and bases

- Arrhenius definition of acid/base theory
- An acid is any substance which delivers an H$^+$ in solution
  - H$^+$ really exists as H$_3$O$^+$ in aqueous solutions (hydronium ion)
- A base is any substance which delivers an OH$^-$ in solution.
Acid Base Neutralization

- Acids react with bases to produce a neutral solution – neither acid nor base
- Produces water and a salt
- Complete equation
Diprotic Acids

- Some acids can donate more than one hydrogen ion
- E.g. $\text{H}_2\text{SO}_4$ and $\text{H}_3\text{PO}_4$
- $\text{H}_2\text{SO}_4 + 2 \text{H}_2\text{O} \rightarrow 2 \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$

Bases

- Bases deliver $\text{OH}^-$ in solution
- Metal hydroxides $\text{MOH}$ and $\text{M(OH)}_2$
- $\text{NaOH}$ and $\text{Ca(OH)}_2$
- Metal oxides (MO) contain $\text{O}^{2-}$
- $\text{O}^{2-} + \text{H}_2\text{O} \rightarrow 2 \text{OH}^-$

Weak Bases

- Some bases react with water to produce an $\text{OH}^-$ in solution
- $\text{NH}_3 + \text{H}_2\text{O} \leftrightarrow \text{NH}_4^+ + \text{OH}^-$
- Weak bases are in equilibrium
- Both the forward and the reverse reaction occur at the same time
4.5. Name and provide the symbol for the seven strong acids and the 4 strong bases.

[Readings 4.5 Problems 16 ]

The Seven Strong Acids

- HCl               hydrochloric acid
- HBr               hydrobromic acid
- HI                hydroiodic acid
- HClO\textsubscript{3}   chloric acid
- HClO\textsubscript{4}  perchloric acid
- HNO\textsubscript{3}   nitric acid
- H\textsubscript{2}SO\textsubscript{4}  sulfuric acid

The Four Strong Bases

- Metal hydroxides Group I and II metals
  - Sodium hydroxide NaOH
  - Calcium hydroxide Ca(OH)\textsubscript{2}
### The Four Strong Bases

- **Metal hydroxides** \( MOH \)
- **Metal hydrides** Group I and II metals \( H \) in solution
  - Sodium hydride \( NaH \)
  - \( H^+ + H_2O \rightarrow H_2(g) + OH^- \)

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- **Metal oxides** \( O^{2-} \) in solution
  - Potassium oxide \( K_2O \)
  - Calcium oxide \( CaO \)
  - \( O^{2-} + H_2O \rightarrow 2 OH^- \)

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- **Metal amides** \( MNH_2 \)
  - Lithium amide \( LiNH_2 \)
  - \( NH_3^- \) in solution
  - \( NH_3^- + H_2O \rightarrow NH_3 + OH^- \)

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The Four Strong Bases

- Metal hydroxides: \( \text{MOH} \)
- Metal hydrides: \( \text{MH} \)
- Metal oxides: \( \text{M}_2\text{O} \)
- Metal amides: \( \text{MNH}_2 \)

4.6. Use solution stoichiometry to calculate the mass of reactants, products, and ions in solution.
[Readings 4.9 Problems 65, 67, 69, 75, & 77] Challenge problems 90 & 93

Practice problem

- Calculate the volume of 0.100M \( \text{NaOH} \) that would be required to completely neutralize 25.00 ml of 0.0582 M \( \text{H}_2\text{SO}_4 \)
- First Step: Write the balanced chemical equation
- Acid base neutralization yields water and a salt
- \( \text{H}_2\text{SO}_4 + 2 \text{NaOH} \rightarrow 2 \text{H}_2\text{O} + \text{Na}_2\text{SO}_4 \)
Challenge Problem

• Suppose you have 500 ml of a solution with an unknown amount of calcium chloride. After the addition of 50.00 ml of a AgNO₃ solution, no more precipitate forms, however you add another 25.0 ml of the AgNO₃ solution, just to be sure. You dry precipitate and find it to weigh 7.166 g. What was the concentration of the original Calcium chloride solution?