HONORS CHEMISTRY

Unit F: ACIDS & BASES

CHAPTER THIRTEEN: IONS IN AQUEOUS SOLUTION
AQUEOUS SOLUTIONS

- AQUEOUS SOLUTIONS are water based solutions
- Ionic and Molecular compounds can be water soluble
- Ionic compounds are composed of ions with ionic bonds
- Molecular compounds are neutral atoms covalently bonded
DISSOCIATION

- DISSOCIATION is the separation of ions that occurs when an ionic compound dissolves.
- Ions are already present.
- The attractive forces between the polar water molecules and the ions is strong enough to overcome the ionic attractions.
Dissociation

HNO₃ + H₂O → NO₃⁻ + H₃O⁺
Nitric acid
Complete dissociation

CH₃COOH + H₂O ← CH₃COO⁻ + H₃O⁺
Acetic acid
Partial dissociation
All IONIC compounds have at least some solubility-some have a very low solubility (INSOLUBLE)

Some double displacement reactions involving IONIC compounds produce a precipitate

PRECIPITATES are insoluble products that form from soluble reactants

SOLUBILITY TABLES are helpful for predicting precipitates
Precipitation Reactions

Precipitate – insoluble solid that separates from solution

\[
Pb(NO_3)_2 (aq) + 2NaI (aq) \rightarrow PbI_2 (s) + 2NaNO_3 (aq)
\]

molecular equation

\[
Pb^{2+} + 2NO_3^- + 2Na^+ + 2I^- \rightarrow PbI_2 (s) + 2Na^+ + 2NO_3^-
\]

ionic equation

\[
Pb^{2+} + 2I^- \rightarrow PbI_2 (s)
\]

net ionic equation

Na\(^+\) and NO\(_3^-\) are spectator ions
### Solubility Table

#### Table 4.1: Solubility Guidelines for Common Ionic Compounds in Water

<table>
<thead>
<tr>
<th>Soluble Ionic Compounds</th>
<th>Important Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compounds containing</td>
<td></td>
</tr>
<tr>
<td>$\text{NO}_3^-$</td>
<td>None</td>
</tr>
<tr>
<td>$\text{CH}_3\text{COO}^-$</td>
<td>None</td>
</tr>
<tr>
<td>$\text{Cl}^-$</td>
<td>Compounds of $\text{Ag}^+$, $\text{Hg}_2^{2+}$, and $\text{Pb}^{2+}$</td>
</tr>
<tr>
<td>$\text{Br}^-$</td>
<td>Compounds of $\text{Ag}^+$, $\text{Hg}_2^{2+}$, and $\text{Pb}^{2+}$</td>
</tr>
<tr>
<td>$\text{I}^-$</td>
<td>Compounds of $\text{Ag}^+$, $\text{Hg}_2^{2+}$, and $\text{Pb}^{2+}$</td>
</tr>
<tr>
<td>$\text{SO}_4^{2-}$</td>
<td>Compounds of $\text{Sr}^{2+}$, $\text{Ba}^{2+}$, $\text{Hg}_2^{2+}$, and $\text{Pb}^{2+}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insoluble Ionic Compounds</th>
<th>Important Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compounds containing</td>
<td></td>
</tr>
<tr>
<td>$\text{S}^{2-}$</td>
<td>Compounds of $\text{NH}_4^+$, the alkali metal cations, and $\text{Ca}^{2+}$, $\text{Sr}^{2+}$, and $\text{Ba}^{2+}$</td>
</tr>
<tr>
<td>$\text{CO}_3^{2-}$</td>
<td>Compounds of $\text{NH}_4^+$ and the alkali metal cations</td>
</tr>
<tr>
<td>$\text{PO}_4^{3-}$</td>
<td>Compounds of $\text{NH}_4^+$ and the alkali metal cations</td>
</tr>
<tr>
<td>$\text{OH}^-$</td>
<td>Compounds of the alkali metal cations, and $\text{NH}_4^+$, $\text{Ca}^{2+}$, $\text{Sr}^{2+}$, and $\text{Ba}^{2+}$</td>
</tr>
</tbody>
</table>

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NET IONIC EQUATIONS

- NET IONIC EQUATIONS include only the compounds and ions that undergo a chemical change in a reaction in an aqueous solution.
- SPECTATOR IONS are present as reactants and products and remain unchanged.
- SPECTATOR IONS are omitted from the NET IONIC EQUATION.
NET IONIC EQUATIONS

Net Ionic Equation of a Neutralization Reaction Involving Strong Acids and Strong Bases

$$\text{CuSO}_4 \text{(aq)} + \text{Zn} \text{(s)} \rightarrow \text{Cu} \text{(s)} + \text{ZnSO}_4 \text{(aq)}$$

$$\text{Cu}^{2+} \text{(aq)} + \text{SO}_4^{2-} \text{(aq)} + \text{Zn} \text{(s)} \rightarrow \text{Cu} \text{(s)} + \text{Zn}^{2+} \text{(aq)} + \text{SO}_4^{2-} \text{(aq)}$$

$$\text{Cu}^{2+} \text{(aq)} + \text{Zn} \text{(s)} \rightarrow \text{Cu} \text{(s)} + \text{Zn}^{2+} \text{(aq)}$$
IONIZATION

- IONIZATION is the process of ions forming in a solution from a solute molecule.
- The solution must be POLAR.
- The energy released as HEAT from the hydration of the molecule is enough to BREAK the covalent (molecule) bonds.
- Strong covalent bonds result in partial ionization.
- Weak covalent bonds result in complete ionization.
IONIZATION

\[
\text{HCl}(g) + \text{H}_2\text{O}(l) \rightarrow \text{Cl}^{-}(aq) + \text{H}_3\text{O}^+(aq)
\]

[16.3]
WATER AUTO-IONIZES – forms the OH$^-$ and H$^+$ ions in solution

\[ 2\text{H}_2\text{O} \leftrightarrow \text{H}_3\text{O}^+ + \text{OH}^- \]
IONIZATION OF WATER

- The H+ ion is highly reactive and forms the H₃O⁺ ion with another water molecule.
- The H₃O⁺ ion is the HYDRONIUM ION and its formation produces much of the energy needed to ionize molecular solutes.
ELECTROLYTE STRENGTH

- **STRONG ELECTROLYTES** are very good conductors of electricity
- Almost all of the dissolved compound is present as **IONS**
- **STRONG ACIDS** are **STRONG ELECTROLYTES**
  - HCl, HBr, H$_2$SO$_4$, HNO$_3$
- Weak electrolytes are poor conductors
- Few ions in solution
- HF, CH$_3$COOH