IONIC REACTIONS IN WATER

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Precipitation Reactions

The “driving force” is the formation of an insoluble compound — a precipitate.

\[
Pb(NO_3)_2(aq) + 2 KI(aq) \rightarrow \]
\[
PbI_2(s) + 2 KNO_3(aq)
\]

Pb(NO_3)_2(aq) + 2 KI(aq) \rightarrow PbI_2(s) + 2 KNO_3(aq)

Net ionic equation

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

Precipitation Reactions

To determine the NIE, first write all reactants in water. If they are soluble, show them ionized.

Pb^{2+}(aq) + NO_3^-(aq) + 2 K^+(aq) + 2 I^-(aq)

Now look at all the combinations

- lead nitrate is soluble
- lead iodide is insoluble
- potassium iodide is soluble
- potassium nitrate is soluble

So the lead ion and iodide ion will react to make a precipitate, with K^+ and NO_3^- remaining in solution as spectators

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

Acid-Base Reactions

- The “driving force” in acid-base reactions is the formation of water.

NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(liq)

- Net ionic equation

OH^-(aq) + H^+(aq) \rightarrow H_2O(liq)

- This applies to ALL reactions of STRONG acids and bases.

Screen 5.7 on the CD-ROM

Screen 5.10 on the CD-ROM
Acid-Base Reactions

To determine the NIE, first write all reactants in water. These are strong electrolytes so show them ionized.

\[
\text{Na}^+(aq) + \text{OH}^-(aq) + \text{H}^+(aq) + \text{Cl}^+(aq)
\]

Look at the ion combinations and remember that \(\text{H}^+\) and \(\text{OH}^-\) react to form water.

\[
\text{OH}^-(aq) + \text{H}^+(aq) \rightarrow \text{H}_2\text{O(liq)}
\]

Acid-Base Reactions

- Acid-base reactions are sometimes called NEUTRALIZATIONS because the solution is neither acidic nor basic at the end, it is neutral.
- The other product of the \(\text{HX-MOH}\) acid-base reaction is a SALT, \(\text{MX}\).

\[
\text{HCl} + \text{LiOH} \rightarrow \text{LiCl} + \text{H}_2\text{O}
\]

\(\text{Li}^+\) comes from base & \(\text{Cl}^-\) comes from acid

The final result is the same as dissolving \(\text{LiCl}\) in water.

Acid-Base Reactions

Not all acid-base reactions are for strong acids and/or bases. For example,

\[
\text{HX} + \text{MOH} \rightarrow \text{MX} + \text{H}_2\text{O}
\]

could represent a reaction of a weak acid and an insoluble hydroxide.

In this case, start with the species as they would be found in water. Take acetic acid and insoluble calcium hydroxide as an example.

\[
\text{CH}_3\text{CO}_2\text{H}(aq) + \text{Ca(OH)}_2(s) \rightarrow \text{??}
\]

Acid-Base Reactions

The acetic acid will ionize slightly, producing a few \(\text{H}^+\) ions. These will react with the \(\text{OH}^-\) of the \(\text{Ca(OH)}_2\) to form water. This will continue until all the \(\text{OH}^-\) is removed from the \(\text{Ca(OH)}_2\), leaving acetate and \(\text{Ca}^{2+}\) ions:

\[
\text{CH}_3\text{CO}_2\text{H}(aq) + \text{Ca(OH)}_2(s) \rightarrow \text{H}_2\text{O(l)} + \text{Ca}^{2+}(aq) + \text{CH}_3\text{CO}_2^-(aq)
\]

This is unbalanced! Must be fixed!
Acid-Base Reactions

\[ \text{CH}_3\text{CO}_2\text{H(aq)} + \text{Ca(OH)}_2(s) \rightarrow \text{H}_2\text{O(l)} + \text{Ca}^{2+}(aq) + \text{CH}_3\text{CO}_2^-(aq) \]

There are two hydroxide ions in each Ca(OH)\textsubscript{2} so we need two acetic acids to make two H\textsuperscript{+} for each molecule of calcium hydroxide.

That would produce two water molecules, or...

\[ 2 \text{CH}_3\text{CO}_2\text{H(aq)} + \text{Ca(OH)}_2(s) \rightarrow 2 \text{H}_2\text{O(l)} + \text{Ca}^{2+}(aq) + 2 \text{CH}_3\text{CO}_2^-(aq) \]

This is the net ionic equation.

Gas-Forming Reactions

- This is often the chemistry of metal carbonates.
  \[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \]
  \[ \text{H}_2\text{CO}_3(aq) + \text{Ca}^{2+} \rightarrow 2 \text{H}^+(aq) + \text{CaCO}_3(s) \text{ (limestone)} \]

- Adding acid reverses this reaction:
  \[ \text{CaCO}_3 + \text{acid} \rightarrow \text{CO}_2 + \text{calcium salt} \]

Gas-Forming Reactions

\[ \text{CaCO}_3(s) + \text{H}_2\text{SO}_4(aq) \rightarrow 2 \text{CaSO}_4(aq) + \text{H}_2\text{CO}_3(aq) \]

Carbonic acid is unstable and forms CO\textsubscript{2} & H\textsubscript{2}O:

\[ \text{H}_2\text{CO}_3(aq) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O(l)} \]

**Antacid tablets use carbonate to make CO\textsubscript{2}**

(Note: the antacid tablet has citric acid + NaHCO\textsubscript{3})

Screen 5.5 on the CD-ROM