Acid Base Properties of Salts

Recommended for Chapter(s): 7

Demo #025

Materials NOT in box

1. Safety goggles.

Procedure

1. Pour 60 mL of each of the solutions into separate 100 mL beakers.
2. Ask students to predict if the solution is acid, basic, or neutral.
3. Write the following chart on the board

<table>
<thead>
<tr>
<th>Color</th>
<th>PH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>2</td>
</tr>
<tr>
<td>Red-Orange</td>
<td>3</td>
</tr>
<tr>
<td>Orange</td>
<td>4</td>
</tr>
<tr>
<td>Orange-Yellow</td>
<td>5</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
</tr>
<tr>
<td>Green</td>
<td>7</td>
</tr>
<tr>
<td>Green-Blue</td>
<td>8</td>
</tr>
<tr>
<td>Green-Violet</td>
<td>9</td>
</tr>
<tr>
<td>Violet</td>
<td>10</td>
</tr>
</tbody>
</table>

4. Put 1 dropper full of universal indication into each of the beakers to identify the pH.
   a. 0.1 M KI solution should turn green (pH = 7.0 neutral).
   b. 0.1 M NH₄Cl solution should turn orange (pH = 4.6 acidic).
   c. 0.1 M NaHSO₃ solution should turn red-orange (pH = 4.5 acidic).
   d. 0.1 M NH₄C₂H₃O₂ solution should turn green (pH = 7.0)
   e. 1.0 M NaC₂H₃O₂ solution should turn blue-green (pH = 8.9 basic)

Safety

1. Wear safety goggles.

Clean Up

1. Pour all solution in waste bottle.
2. Return the materials to the cart in the demonstration library room.

Stockroom Notes

1. Empty waste bottle down the drain with plenty of water.
2. Replace glassware with clean glassware.
3. If needed refill any material that is used up.
a. Make sure at least 100 mL of each solution.
b. When refilling the universal indicator make sure that you use Fisher universal indicator (S80043A) it should be green in color.

4. Return items to demonstration tub.
5. Return tub to the demonstration library.
   a. Goggles go in the goggle box

**Discussion**

The acid base properties of salts can be determined by looking at what type of acid and base could have formed the salt. The following chart summarizes the acid/base properties of salts. For example the salt NaCl could have been formed by reaction the strong acid HCl and a strong base NaOH in the following reaction $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ therefore, according to the chart NaCl is neutral.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Base</th>
<th>Salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong Acid</td>
<td>Strong Base</td>
<td>Neutral</td>
</tr>
<tr>
<td>Strong Acid</td>
<td>Weak Base</td>
<td>Acidic</td>
</tr>
<tr>
<td>Weak Acid</td>
<td>Strong Base</td>
<td>Basic</td>
</tr>
<tr>
<td>Weak Acid</td>
<td>Weak Base</td>
<td>$K_a &gt; K_b$ Acidic, $K_a &lt; K_b$ Basic, $K_a = K_b$ Neutral</td>
</tr>
</tbody>
</table>

* $K_a$ and $K_b$ are of values for the salt ions

**KI**

$K^+$ came from KOH which is a strong base.
$I^-$ came from HI which is a strong acid.
Therefore the solution will be neutral. (pH = 7.0)

**NH₄Cl**

$NH_4^+$ came from NH₃ which is a weak base.
$Cl^-$ came from HCl which is a strong acid.
Therefore the solution will be acidic. (pH = 4.6)
NaHSO₃
Na⁺ came from NaOH which is a strong base.
HSO₃⁻ came from H₂SO₃ which is a weak acid.
However since H₂SO₃ is polyprotic acid both of the following reactions must be considered:

\[
\text{HSO}_3^-(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{SO}_3(aq) + \text{OH}^-(aq) \quad K_b=6.7 \times 10^{-13}
\]

and

\[
\text{HSO}_3^-(aq) \rightleftharpoons \text{SO}_3^{2-}(aq) + \text{H}^+(aq) \quad K_a=1.0 \times 10^{-7}
\]

Since $K_a$ is larger than $K_b$ the solution will be acidic. (pH = 4.5)

NH₄C₂H₃O₂
NH₄⁺ came from NH₃ which is a weak base.
C₂H₃O₂⁻ came from HC₂H₃O₂ which is a weak acid.
Need to compare $K_a$ and $K_b$ values

\[
K_a = \frac{K_w}{K_{b(NH_3)}} = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}
\]

\[
K_b = \frac{K_w}{K_{a(HC_2H_3O_2)}} = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}
\]

Since $K_a=K_b$ the solution will be neutral. (pH = 7.0)

NaC₂H₃O₂
Na⁺ came from NaOH which is a strong base.
C₂H₃O₂⁻ came from HC₂H₃O₂ which is a weak acid.
Therefore, the solution will be basic. (pH = 8.8)

$K_a/K_b$ values for weak acids/bases of interest in this demonstration.

<table>
<thead>
<tr>
<th>Acid/Base</th>
<th>What ion it would form in a salt</th>
<th>$K_a$ (Ion)</th>
<th>$K_b$ (Ion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>NH₄⁺</td>
<td>1.8×10⁻³</td>
<td></td>
</tr>
<tr>
<td>H₂SO₃</td>
<td>HSO₃⁻, SO₃²⁻</td>
<td>$K_{a1}=1.5 \times 10^{-2}$</td>
<td>$K_{a2}=1.0 \times 10^{-7}$</td>
</tr>
<tr>
<td>HC₂H₃O₂</td>
<td>C₂H₃O₂⁻</td>
<td>1.8×10⁻³</td>
<td></td>
</tr>
</tbody>
</table>
Materials for demo 025
1. 0.1 M KI
2. 0.1 M NH₄Cl
3. 0.1 M NaHSO₄
4. 0.1 M NH₄C₂H₃O₂
5. 1.0 M NaC₂H₃O₂
6. Five 100 mL beakers
7. Five Glass stir rods
8. Waste bottle
9. Universal Indicator (Fisher S80043A)