Titration Problems

1. Explain the difference between the endpoint and the equivalence point of a titration.

2. Explain how you could determine the molarity of 15.00mL of HCl that was titrated with 8.21mL of sodium hydroxide.

3. If it takes 34.02mL of 0.150M sodium hydroxide to completely neutralize 50.00mL of hydrochloric acid, what is the molarity of the acid?

4. If it takes 34.02mL of 0.150M sodium hydroxide to completely neutralize 50.00mL of acetic acid, what is the molarity of the acid?

5. If it takes 34.02mL of 0.150M sodium hydroxide to completely neutralize 50.00mL of sulfuric acid, what is the molarity of the acid?

6. Explain any similarities or differences found in the answers to #3, #4, and #5.

7. Challenge: What can make the titrated solution at the equivalence point in an acid-base titration have a pH not equal to 7.00. How does this possibility affect the choice of an indicator?
When choosing indicators for reactions, you need to identify the type of reaction and the relative pH at the equivalence point.

<table>
<thead>
<tr>
<th>Acid Type</th>
<th>Base Type</th>
<th>Resulting pH range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong Acid</td>
<td>Strong Base</td>
<td>~ 7</td>
</tr>
<tr>
<td>Weak Acid</td>
<td>Strong Base</td>
<td>Basic pH &gt; 7</td>
</tr>
<tr>
<td>Strong Acid</td>
<td>Weak Base</td>
<td>Acidic pH &lt; 7</td>
</tr>
</tbody>
</table>

8. Use table 22 in your data booklet to identify a good indicator for titrating potassium hydroxide (strong base) with hydrobromic acid (strong acid)? Explain.

9. When 50 mL of 0.10 M formic acid (weak acid) is titrated with 0.10 M sodium hydroxide (strong base) the pH at the equivalence point is 8.35. Use table 22 in your data booklet to identify a good indicator for this titration?

10. For each of the following titration, specify the indicator from column II that should be used. State your reasons, but do not make any quantitative calculations.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) NaOH (strong base) + KHC₆H₄O₄ (weak acid)</td>
<td>bromocresol green (2.8-5.4)</td>
</tr>
<tr>
<td>b) NaOH (strong base) + HCl (strong acid)</td>
<td>neutral red (6.8-8.0)</td>
</tr>
<tr>
<td>c) NaHCO₃ (weak base) + HCl (strong acid)</td>
<td>0-cresolphthalein (8.2-9.8)</td>
</tr>
</tbody>
</table>
**Answer Key**

1. end point = color change during a titration, stop adding titrant  
equivalence point = point in titration where moles acid = moles base

2. It is not possible to find the molarity of the HCl. You must know the concentration of the NaOH to be able to find the concentration of the HCl.

3. 0.102M HCl

4. 0.102M CH₃COOH

5. 0.0510M H₂SO₄

6. #3 and #4 1:1 ratio of acid to base, therefore same molarity  
#5 1:2 ratio of acid to base  
Strong or weak acid makes no difference

7. If the salt present at the equivalence point has an anion that is the conjugate base of a weak acid pH > 7. If the salt present at the equivalence point has a cation that is the conjugate acid of a weak base pH < 7. One must choose an indicator that changes color close the pH at the equivalence point.

8. KBr pH = 7 Possible indicators include methyl red, chlorophenol red, bromthymol blue, phenol red, neutral red, thymol blue, phenolphthalein or any other indicator that changes color near 7.

9. phenolphthalein would be best because it changes color starting at 8.3.

10. a. basic salt: 0-cresolphthalein

   b. neutral salt: neutral red

   c. acidic salt: bromocresol green