1. What is the relationship between acid strength, $K_a$, and $pK_a$?

2. Show the equation using condensed structures for the reaction between ammonium ion (NH$_4^+$) and methoxide ion (CH$_3$O$^-$).
   a. Label the conjugate pairs
   b. Circle the stronger acid
   c. Calculate the approximate $K_{eq}$
   d. Which direction does the equilibrium lie?

3. Show the equation using skeletal structures for the reaction between acetate ion (CH$_3$COO$^-$) and protonated ethanol (CH$_3$CH$_2$OH$^+$).
   a. Label the conjugate pairs
   b. Circle the stronger acid
   c. Calculate the approximate $K_{eq}$
   d. Which direction does the equilibrium lie?

4. What is the resulting pH if 5 moles of ammonia were mixed with 5 moles of ammonium chloride ($pK_a = 9.4$)? What is the pH if the molar ratio was 1:10 or 100:1 respectively?

5. Rank the following by increasing acid strength. Explain your reasoning.
   a. HF  HCl  HBr  HI
   b. H$_2$S  H$_2$Se  H$_2$O
   c. HF  H$_2$O  NH$_3$
   d. CH$_3$OH  CF$_3$OH  ClCH$_2$OH
   e. 
      ![Chemical structures]
   f. FCH$_2$OH  HCO$_2$H
   g. 
      ![Chemical structures]
   h. HC≡CH  H$_2$C=CH$_2$  CH$_3$CH$_3$
   i. CH$_3$NH$_2$ or CH$_3$NH$_3^+$
6. Predict the stronger base.
   a. NH₃ or PH₃
   b. CH₃O⁻ or CF₃O⁻
   c. CH₃O⁻ or CH₃NH⁻
   d. 
   e. 
   f. 

7. Rank the following by increasing base strength:

8. Lysine is a naturally occurring amino acid. Given lysine’s structure answer the following.

   a. Why is the pKa of the carboxylic acid in lysing so much lower than acetic acid?
   b. Draw the structure of lysine at pH = 0.
   c. Draw the structure of lysine at pH = 7.4
   d. Is there a pH at which lysine will have no atoms with a formal charge? Explain
Comparing Relative Acid Strength

Are the acidic hydrogens on the same element?

1. No
   A. Same period elements ⇒ acid strength increases with increasing electronegativity
   B. Different period elements ⇒ acid strength increases with increasing atomic radius

2. Yes
   A. Formal charge ⇒ Acid strength increases with increasing + charge
   B. Hybridization ⇒ Acid strength increases with increasing s character (sp > sp² > sp³)
   C. Resonance ⇒ Acid strength increases with withdrawing electrons via delocalization
   D. Induction ⇒ Acid strength increases with withdrawing electrons due to induction

<table>
<thead>
<tr>
<th>Compounds</th>
<th>pKₐ</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₃O⁺ or ROH₂⁺ or</td>
<td>&lt; 0</td>
</tr>
<tr>
<td>OH⁻ or</td>
<td>~5</td>
</tr>
<tr>
<td>R—O</td>
<td></td>
</tr>
<tr>
<td>NH₄⁺ or RNH₂⁺ or</td>
<td>~10</td>
</tr>
<tr>
<td>R—OH or</td>
<td>~15</td>
</tr>
<tr>
<td>H₂O or ROH</td>
<td>~25</td>
</tr>
<tr>
<td>H—C≡C—H</td>
<td>~35-40</td>
</tr>
<tr>
<td>RNH₂</td>
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</tr>
<tr>
<td>H₂C=CH₂</td>
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<tr>
<td>CH₂CH₃</td>
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