1. Rank the following molecules in terms of increasing pKa of the hydrogen atom drawn.

   B < A = D < E < C

Greater pKa indicates a weaker acid.
Fluorine is more electronegative than bromine.
Electronegative atoms closer to the acidic hydrogen have a greater electron-withdrawing effect.
The more electronegative atoms closer to the acidic hydrogen, the greater the electron-withdrawing effect on the hydrogen.
Thus...
B is more acidic than A and has a lower pKa.
A and D are the same molecule. pKa’s are equal.
Bromine is less electronegative than fluorine and although it is closer to the acidic hydrogen, it’s effects do not supercede those of two fluroines seen in A and D.
C contains no electronegative atoms besides the carbonyl oxygen. It has the greatest pKa.
2. Draw three resonance structures for the following molecule.

![Resonance structures](image)

3. Below is acetylcholine, a neurotransmitter found in the human body.
   a. Indicate all functional groups.
      Ester
      Quarternary amine
      Pink: carbonyl
      Green: ester
      Red: quartenary amine
b. Add lone pairs and charges where necessary.  
See below.

![Molecule Diagram]

\[
\begin{align*}
\text{C}_p\text{-O}_p \text{ (pi bond)}, & \quad \text{and } \text{C}_{sp^2}\text{-O}_{sp^2} \\
\text{C}_p\text{-O}_p \text{ (pi bond)}, & \quad \text{and } \text{C}_{sp^2}\text{-O}_{sp^2} \\
\end{align*}
\]

c. Identify the orbitals that consist of the double bond between oxygen and carbon.  
\[\text{C}_p\text{-O}_p \text{ (pi bond)}, \quad \text{and } \text{C}_{sp^2}\text{-O}_{sp^2}\]
d. Are the oxygen molecules hydrogen bond donors, acceptors or neither?  
Both are hydrogen bond acceptors but not donors because they lack hydrogens.
e. Is the nitrogen atom a hydrogen bond donor, acceptor or neither?  
Neither: nitrogen is unavailable for bonding with other molecules. It has no lone pairs.

4. Predict the products, if any, in the following reaction. Explain your reasoning.

\[
\begin{align*}
\text{Why?} \\
\text{Scenario #1} \\
\text{Base} \quad \text{Acid, } pK_a = 44 & \Rightarrow \text{Conjugate Acid, } pK_a < 0 \\
& \Rightarrow \text{Conjugate Base} \\
& \text{VERY Strong} \\
\text{pK}_a \text{ of the conjugate acid is less than that of the acid. Acid-base reactions favor the weaker acid and base: the reaction favors the left and will not proceed.} \\
\text{Why?} \\
\text{Scenario #2} \\
\text{Acid, } pK_a = 15 & \Rightarrow \text{Conjugate Base} \\
& \text{Strong} \\
& \Rightarrow \text{Conjugate Acid, } pK_a = 10 \\
& \text{pK}_a \text{ of the conjugate acid is less than that of the acid. Acid-base reactions favor the weaker acid and base: the reaction favors the left and will not proceed.}
\end{align*}
\]
The primary amine is more basic than the amide nitrogen because the amide nitrogen is near oxygen, which can withdraw electrons from nitrogen. See resonance structure below where nitrogen has a positive charge.

**5.**

OH is not protonated because the pKa of a protonated hydroxyl is similar to the pKa of HCl.
6. a. Which compound has the longest C-N bond? ____A____
b. Which compound has the shortest C-H bond? ____C____
c. Which compound has the strongest N-H bond? ____C____
d. Which compound has the weakest C-N bond? ____A____
e. Which compound has the most basic nitrogen? ____A____

7. See below

![Diagram of chemical structures]

a. Major contributor has positive charge near an EDG and is surrounded by two non-hydrogen groups

b.
8. 
   a. Which compound has the carbon with the greatest partial positive charge? _____ C _____
   b. Which compounds have an electron rich carbon? _____ A _____
   c. Which compounds have an electron poor carbon? _____ B,C,D _____

9. **Amine; Ester; Ether; Phenyl** (above)
   a. N (Amine): sp³; C (Ester): sp³; C (Phenyl): sp³
   b. N (Amine): Trigonal Pyramidal; C (Ester): Trigonal Planar; C (Phenyl): Trigonal Planar
   c. N (Amine): (sigma) Nsp³-Csp³ ; (sigma) Nsp³-Csp³ ; (sigma) Nsp³-Csp³
      C (Ester): (sigma) Csp²-Osp² ; (pi) Cp-Op ; (sigma) Csp²-Csp³ ; (sigma) Csp²-Osp³
      C (Phenyl): (sigma) Csp²-Csp² ; (pi) Cp-Cp ; (sigma) Csp²-Csp² ; (sigma) Csp²-Hs
10. Draw the skeletal structures for the following molecules and complete the table below

<table>
<thead>
<tr>
<th></th>
<th>$^+\text{C(\text{CH}_3)_2\text{CH}_2\text{F}}$</th>
<th>$^-\text{C(\text{CH}_3)_2\text{CH}_2\text{F}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbital hybridization about central atom</td>
<td>sp$^2$</td>
<td>sp$^3$</td>
</tr>
<tr>
<td>Molecular geometry</td>
<td>Trigonal planar</td>
<td>Trigonal pyramidal</td>
</tr>
<tr>
<td>Bond angle for central atom</td>
<td>120</td>
<td>&lt;109.5</td>
</tr>
<tr>
<td>Are there dipole moments?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Is there a net dipole moment?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lewis acid or Lewis base?</td>
<td>Lewis acid</td>
<td>Lewis base</td>
</tr>
<tr>
<td>Octet rule satisfied?</td>
<td>No (too few electrons)</td>
<td>Yes</td>
</tr>
</tbody>
</table>