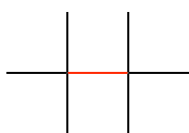
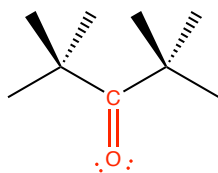


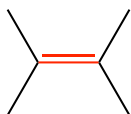
**Chemical Functional Groups:** Study these chemical functional groups until you can recognize them.



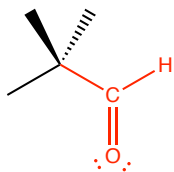
**Alkane**



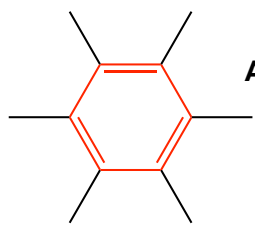
**Carbonyl**



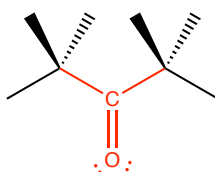
**Alkene**



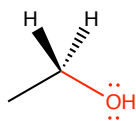
**Aldehyde**



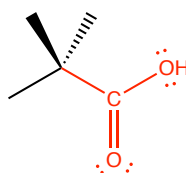
**Aromatic Ring**



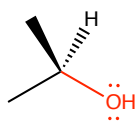
**Ketone**



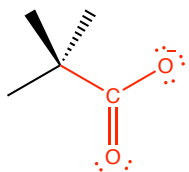
**Primary Alcohol**



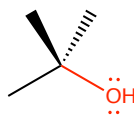
**Carboxylic Acid**



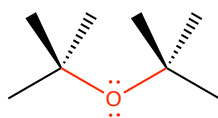
**Secondary Alcohol**



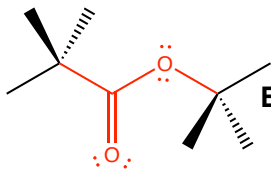
**Carboxylate**



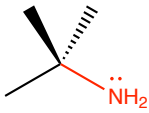
**Tertiary Alcohol**



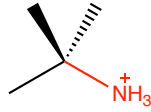
**Ether**



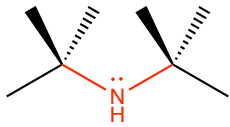
**Ester**



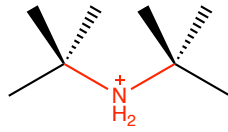
**Primary Amine**



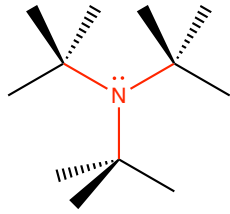
**Primary Ammonium Ion**



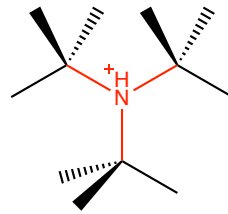
**Secondary Amine**



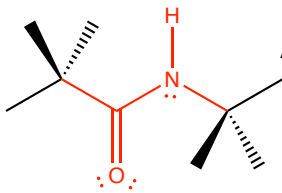
**Secondary Ammonium Ion**



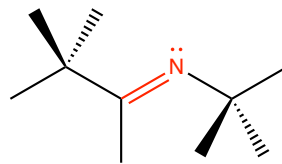
**Tertiary Amine**



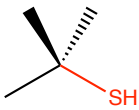
**Tertiary Ammonium Ion**



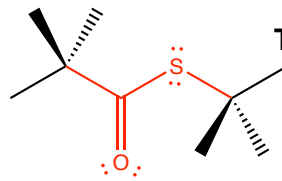
**Amide**



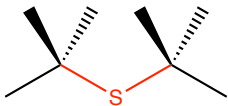
**Imine**



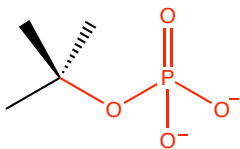
**Thiol**



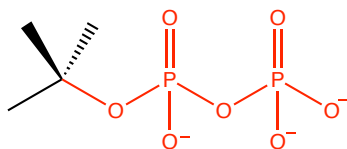
**Thioester**



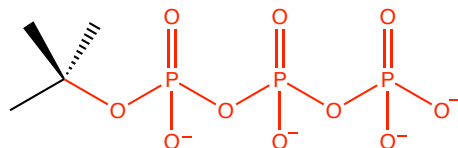
**Sulfide**



**Monophosphate**



**Diphosphate**



**Triphosphate**

1. Draw the chemical structure of each amino acid for yourself. Identify every chemical functional group of each amino acid sidechain.

---

**Hydrogen Bond Acceptors/Donors:** "Polar molecules containing O-H and N-H bonds and the molecule HF have very large dipole moments and stronger than average dipole-dipole interactions. The hydrogen atoms in these molecules are bonded to small, highly electronegative atoms and have large partial positive charge. Therefore, the unequal distribution of the electrons in these molecules gives rise to large dipole moments. Because of its strength, the interaction between the partially positive hydrogen atom on one molecule and a partially negative O, N, or F atom with unshared pairs of electrons on an adjacent molecule merits special distinction: it is called a hydrogen bond"

[Gilbert, Kirss, Foster, and Davies. **Chemistry, 2<sup>nd</sup> Ed.** 2009. pp. 473-474]

2. Review the structures of the amino acids.
  - Identify each sidechain position that is a hydrogen bond donation site.
  - Identify each sidechain position that is a hydrogen bond accepting site.

---

**Brønsted-Lowry acids and bases:** "In 1923, the Danish chemist Johannes Brønsted and the English chemist Thomas Lowry independently proposed the following definitions: an acid is a proton donor, and a base is a proton acceptor."

[Brown and Foote. **Organic Chemistry, 2<sup>nd</sup> Ed.** 1998. p. 102]

3. Review the structures of the amino acids.
  - Identify each sidechain that may act as a Brønsted-Lowry acid.
  - Identify each sidechain that may act as a Brønsted-Lowry base.

---

#### 4. Acid/Base Equilibria

$$pK_a = -\log_{10}(K_a) \quad HA \overset{K_a}{\rightleftharpoons} A^- + H^+$$

- A. Define the equilibrium constant  $K_a$  in terms of  $[HA]$ ,  $[A^-]$ , and  $[H^+]$ .
- B. Rearrange your equation from "A" to isolate  $[H^+]$ .
- C. Take the logarithm of each side of your equation from "B" and subsequently multiply by negative one. This should result in an equation that relates pH to  $pK_a$  and the ratio of the concentrations of the acid and conjugate base forms.

- D. The pKa of the carboxylic acid groups are approximately 4.
- When the pH of the solution is 2, draw the Lewis structure of the predominant form?
  - When the pH of the solution is 4, draw the Lewis structure of the predominant form?
  - When the pH of the solution is 6, draw the Lewis structure of the predominant form?
  - What is the concentration of the conjugate base of acetic acid (in units of M) in a 2 M acetic acid solution at pH 5.2? (pKa = 4.76)
- 

5. **Nucleophilic Substitution:** Consider the reaction(s) between propionic acid and 1-hexanamine. The formation of an amide follows the nucleophilic substitution mechanism similar to a Fischer Esterification. Draw the electron pushing mechanism for this reaction utilizing these reagents.
- Proton transfer from the conjugate acid primary ammonium ion to the carbonyl oxygen increases the electrophilicity of the carbonyl carbon.
  - The lone pair on the deprotonated amine adds to the carbonyl carbon. The hybridization of this carbon changes from  $sp^2$  to  $sp^3$ .
  - A proton is transferred from the resulting secondary ammonium ion to one of the hydroxyl oxygens.
  - The lone pair of the resulting secondary amine adds to the adjacent carbon with the loss of water from the oxonium ion. The hybridization of the carbon changes from  $sp^3$  to  $sp^2$ .
  - The imide undergoes a tautomerization reaction to the amide form.