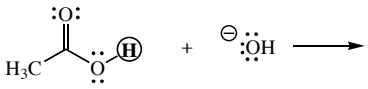
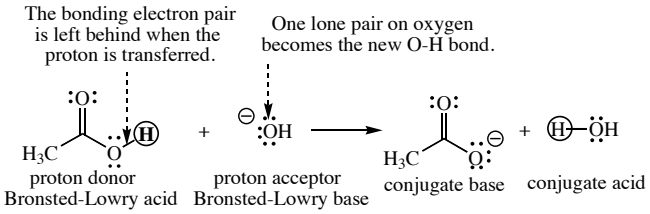
Acids and Bases: Conjugate Acids and Bases

Proton transfers are key features of many organic and biochemical reactions. If a reactant accepts a proton (a Bronsted-Lowry base) the product is termed the conjugate acid of that base. An electron pair from the Bronsted-Lowry base is shared with the proton to make a new bond. If a reactant donates a proton (a Bronsted-Lowry acid), the product is the conjugate base of that acid. The electron pair that was the bond to the transferred proton is left behind as part of the conjugate base. As a fundamental skill necessary to master proton transfer reactions, you will need to be able to draw the conjugates of an acid or base.

Example 1: Provide the products of the following proton transfer reaction. The proton that is transferred is circled. Label all reactants and products as Bronsted-Lowry or conjugate acids and bases.

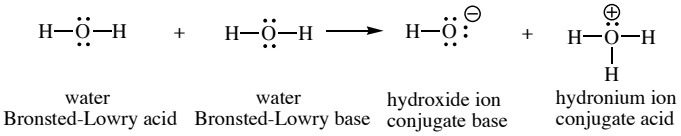


Solution:



Example 2: A small portion of the molecules in liquid water have reacted by proton transfer. This process is termed auto-ionization. Write an equation for the auto-ionization of water that clearly illustrates this proton transfer. Name all the products. Label all reactants and products as Bronsted-Lowry or conjugate acids and bases.

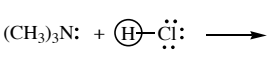
Solution:

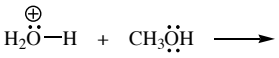


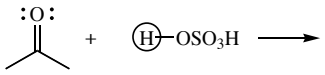
Note that some compounds such as water in this example can function as either an acid or base. Such compounds are termed amphoteric. Where a compound is an acid or base is not controlled solely by molecular structure, but rather by the molecule's role in the reaction.

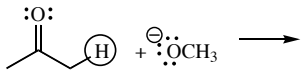
Exercises

1. Provide the products of each proton transfer reactions shown below. In each case, the proton that is transferred is circled. Label all reactants and products as Bronsted-Lowry or conjugate acids and bases.

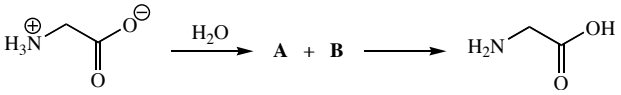
(a) 

(c) 

(b) 

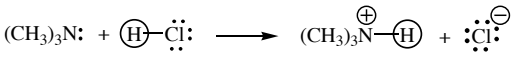
(d) 

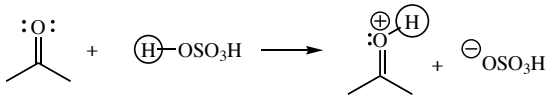
2. The following proton transfer involves two steps. What are the structures of intermediates **A** and **B**?

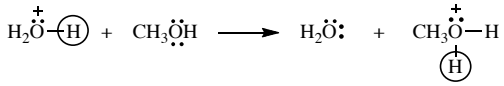


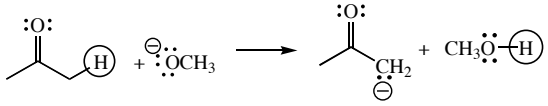
Exercise Solutions

1. The base uses an electron pair to make the new bond with the proton that is transferred. The pair of electrons that used to be the bond to the transferred proton of the acid becomes sole property of the atom to which the proton was bonded. Be sure to consider formal charges as well. Because the atom that used to be attached to the proton gains a pair of electrons that it used to share its charge becomes one unit more negative. The atom of the base that accepts the proton now shares a pair of electrons that formerly were not shared, so its charge becomes one unit more positive.

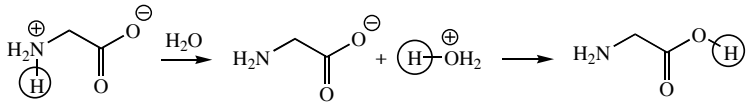
(a) 

(b) 

(c) 

(d) 

2. In the first step, water serves as a base to remove a proton from the ammonium end of glycine, forming an amine and a hydronium ion. The carboxylate ion end of glycine then removes a proton from the hydronium ion. The proton that is shuttled in this manner is circled.



Alternately, carboxylate group of glycine (RCO_2^-) may accept a proton from water, forming a carboxylic acid and hydroxide ion. Hydroxide ion then deprotonates the ammonium group (RNH_3^+) of glycine.