# Tips on Solving Acid-Base Problems in Organic Chemistry

Predicting the products and direction of an acid-base reaction can seem difficult at first until you understand a few simple tricks that can help get you started. You must begin by identifying the acid and base on the left side of the equation. Below are some things I would look for.

1. Are either of the reactants a classic strong acid, such as HCl, HBr, HI, or $H_3O^+$? If so, that compound will be the acid in the reaction and the other reactant will be the base. For example:

   $CH_3CH_2–OH + HI \longrightarrow ?$ HI is the acid and $CH_3CH_2–OH$ is the base.

   Remember, the base will always have an unshared electron pair. In this reaction the hydrogen of the HI will protonate the oxygen of the alcohol to produce $I^{1-}$ and $CH_3CH_2–OH_2^{1+}$ .

2. Do any of the reactants contain the metals Na, K, Li, Mg? These metals can be considered as cations that do not play a role in the reaction (spectator ions). The thing to which they are attached can be considered as an anion that will most likely be the base in the reaction. Species with a negative charge will usually be the base in a reaction. For example:

   $NaNH_2 + H_2O \longrightarrow ?$ $NH_2^{1-}$ is the base and water acts as an acid.

   Water will lose a hydrogen ion and the products will be $NH_3$ and $Na^{1+} + OH^{1-}$ .

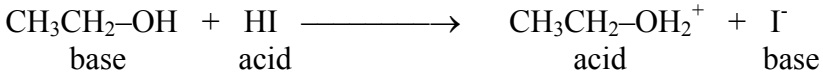
3. Does either reactant contain Al or B atoms with three repulsions, such as $AlCl_3$ or $BF_3$ . These reactions are termed “Lewis acid-base reactions” and usually the formation of a Lewis acid-base complex. This occurs when an unshared electron pair on the base is donated into the empty orbital on the Lewis acid (Al or B). A proton transfer does not occur. For example:

   $AlCl_3 + :NH_3 \longrightarrow ?$ $NH_3$ is the base and $AlCl_3$ is the acid.

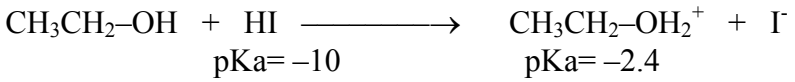
   The product is $Cl_3Al^- – {}^+NH_3$ which has a negative charge on the Al atom and a positive charge on the nitrogen. This is a Lewis acid-base complex. No further reaction can easily be predicted without additional considerations.

4. Some other points to remember. All bases must have an unshared electron pair. Hydrogen atoms on $sp^2$ and $sp^3$ hybridized carbon atoms are not normally removed in acid-base reactions. Hydrogen atoms on O and N and sp hybridized C atoms are frequently removed. Water and ammonia can either lose or gain a H ion. Alcohols (R-OH) can either lose or gain H just like water to form $R\text{-}O^{1-}$ (alkoxide ion) or $R\text{-}OH_2^+$ (protonated alcohol).

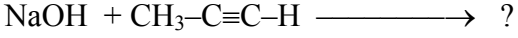
5. Once you have predicted the acid and base in the reactants and have predicted the products, you should remember that the products are also acids and bases. What was an acid on the left side of the equation becomes the conjugate base on the right side. What was the base on the left becomes the acid on the right when it picks up the proton.




6. To predict the DIRECTION of the reaction (as written or to the left) we must consider which of the two acids is the stronger. The reaction will always proceed from the strong acid – strong base pair to the weak acid – weak base pair. We use pKa's to judge acid strength. The higher the pKa is the weaker the acid.

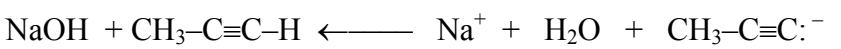



Because HI is a much stronger acid than protonated ethyl alcohol, the reaction proceed toward the weaker acid. This means the reaction proceeds as written.

Consider the reaction 


We predict the products as 

. Acetylene is the acid on the left and water is the acid on the right. The pKa of water is 16 and the pKa of acetylene is about 25. As water is a much stronger acid than acetylene, the reaction proceeds to the left and NOT as written.




Have fun with those acids and bases!