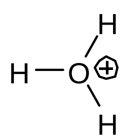
Chemistry 2331H Tuesday, September 17

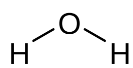
Workshop 5 Solutions
Ranking Acids and Bases

1.

rank



1



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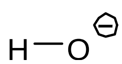
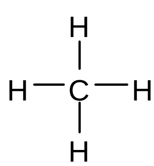


3

In general, for acids with multiple protons, each successive proton is more difficult to remove, so that's one reason why. But thinking about it another way, in losing a proton,

- H_3O^+ (charged) becomes H_2O (neutral). Energetically speaking, that's favorable.
- H_2O (neutral) becomes OH^- (charged). Not so good.
- OH^- would become O^{2-}, but O^{2-} is so unstable it doesn't exist.

rank



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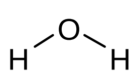

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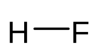
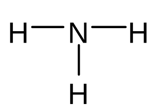


1

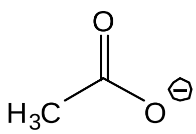


3

Each of these acids generates an anionic conjugate base (CH_3^-, OH^-, F^-, NH_2^-). The relative stability of these ion products determines the acidity of the the acids. Of the charged atoms in those ions, fluorine is the most electronegative and supports the charge the best. So HF is most acidic, followed in order by less electronegative conjugate bases.

2.

rank



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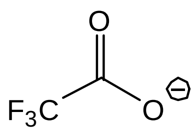

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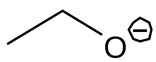
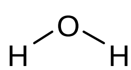


1

Of these anions, resonance stabilizes the top two. So the bottom anion is least stable and most basic. The other two anions have the same resonance structures. However, the trifluoroacetate anion is further stabilized by induction by the three fluorines. So this ion is most stable, and least basic.

rank



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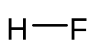

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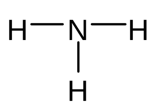
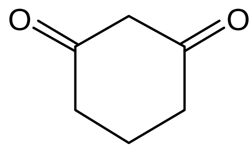


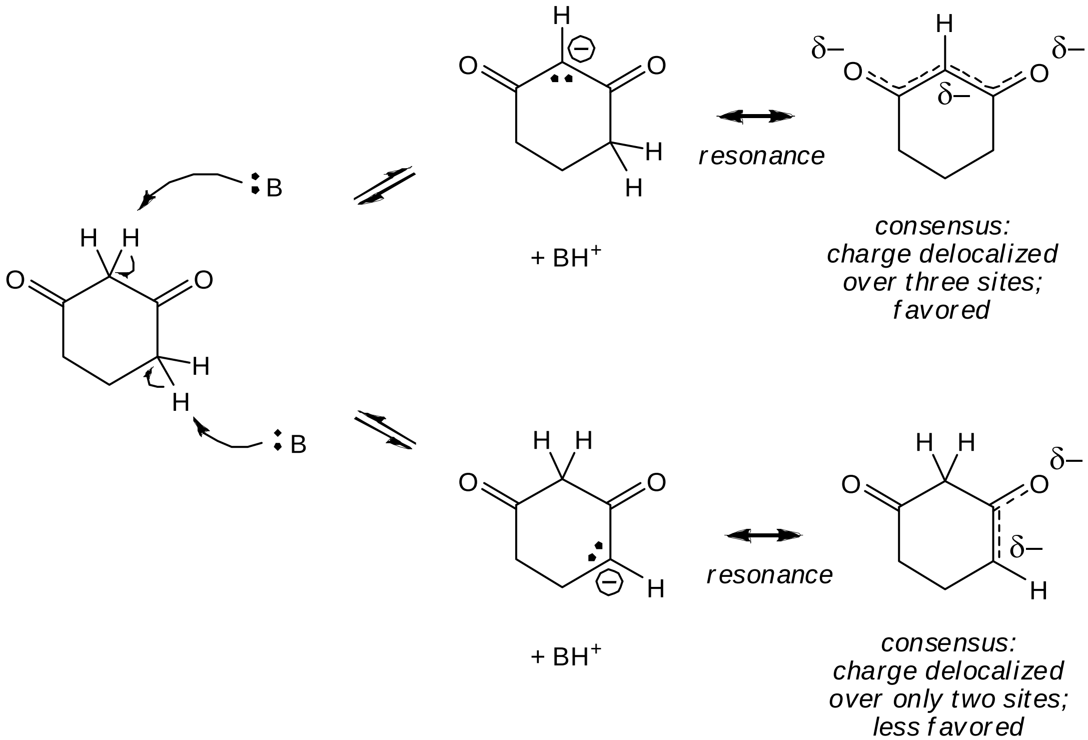
1

Remember, we are thinking of these molecules as *bases* now, not acids. Each generates a cationic conjugate acid (H_3O^+, H_2F^+, NH_4^+). The relative stability of these ion products determines the basicity of the the bases. Of the charged atoms in those ions, fluorine is the most electronegative and supports the positive charge the worst; HF will avoid forming this species, and would be the worst base. HF is followed by the next electronegative centers.

3.

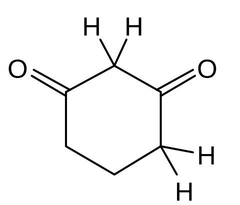


At first, you might have looked at this molecule and asked yourself, where does this molecule have acidic protons? Well, it does have H's, and in the presence of a strong enough base, they would be taken as H^+. So what would that process leave behind?

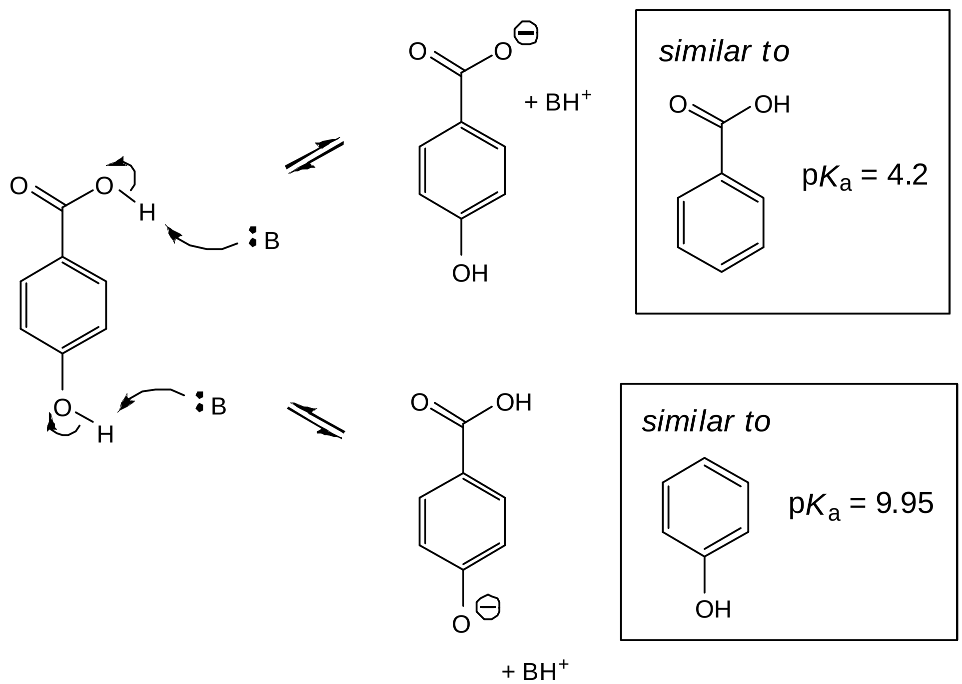


So,

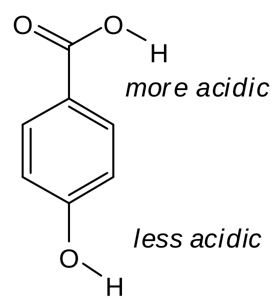
more acidic



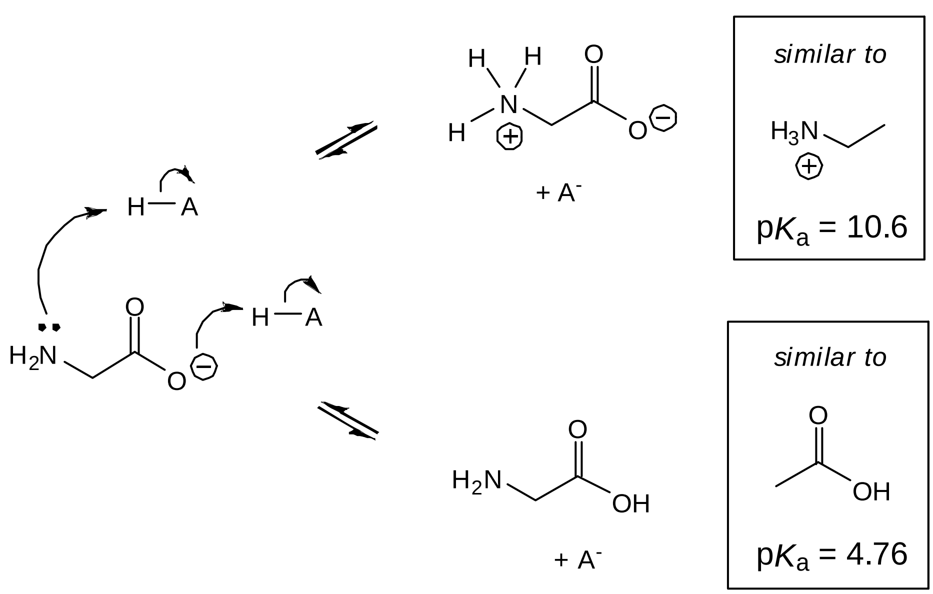
less acidic



So,



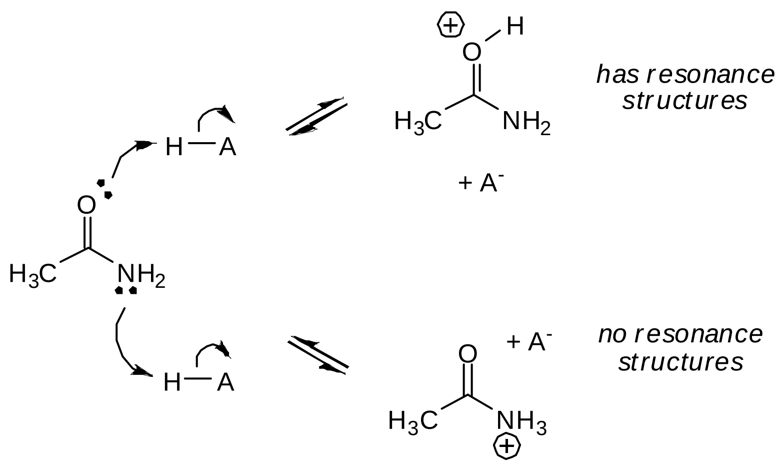
4. Glycine can add a proton to either nitrogen or oxygen, to generate two different conjugate acids. We can evaluate the relative basicity of the sites by looking at the acidity of the conjugate acids generated by protonation:



Out of the two model acids in the boxes on the right, acetic acid (bottom) is stronger than the ethylammonium ion (top). So, because stronger acids mean weaker conjugate bases, the nitrogen lone pair should be more basic than the oxygen.

The interesting surprise here, of course, is that the preferred protonation leads to a zwitterion—that the preferred product has both a positive and a negative charge. That's actually not that unusual for acid-base reactions. For example, most of the large biological molecules in your body are multiply charged.

We actually discussed the second one (or something like it) in class:



So, the oxygen is more basic than nitrogen, because the equilibrium for oxygen protonation lies farther to the right.