Chemistry 2301

Workshop 6
Ranking Acids and Bases

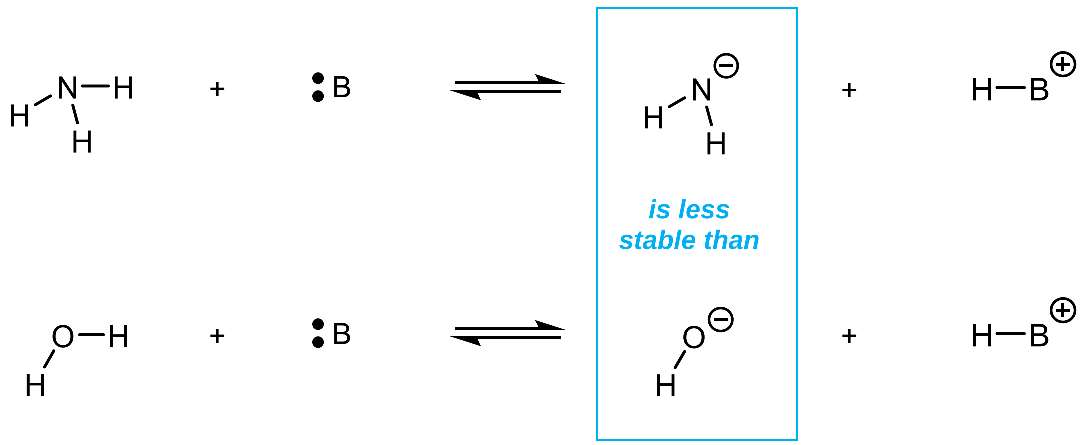
As I mentioned in class, I think of all acid-base questions in terms of equilibria and charge. In order to evaluate the relative strength of an acid or base, we need to:

(i) construct an acid-base equilibrium that shows the acid or base doing its job;

(ii) look to see whether charge is accommodated well or poorly in the starting material or (conjugate) product; and

(iii) conclude whether the acid or base is good (wants to go to product) or bad (wants to stay starting material).

In class, for example, we compared the acidity of ammonia (NH_3) and water (H_2O). To do this, we: (i) drew acid-base equilibria where we showed the two molecules acting as acids; (ii) compared charged species in those equilibria; and (iii) decided which acid is better by concluding which reaction wants to go to product more:



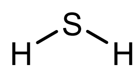
Here, NH_3 doesn't want to make $^-NH_2$ as much as H_2O wants to make ^-OH, because the negative charge. That makes NH_3 a worse acid than H_2O.

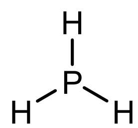
I think you can use this sort of analysis for any acid and any base. When a problem asks you to compare the acidity or basicity of two molecules, it's inviting you to go through the analysis above: compose equilibria, find charged species you can compare—they might be on the reactant or product side—judge the relative stability of those species, and use that information to decide which acid or base is best.

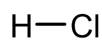
Let's try it out!

1. For each of the sets of ***acids*** below, rank the molecules from 1 (most acidic) to 3 (least acidic) *without* consulting a pK_a chart. For each set, I've left you space to compose model acid-base equilibria; these might help you answer.

rank







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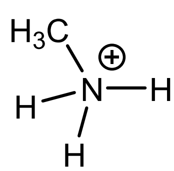
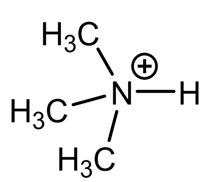
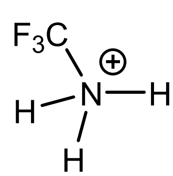
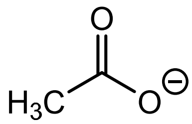


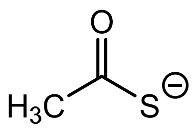


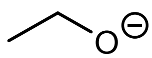


2. For each of the sets of ***bases*** below, rank the molecules from 1 (most basic) to 3 (least basic) *without* consulting a pK_a chart.

rank







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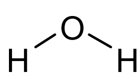
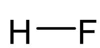
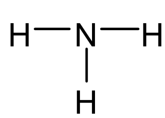
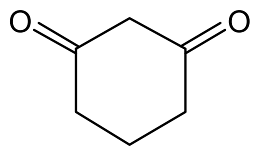
rank

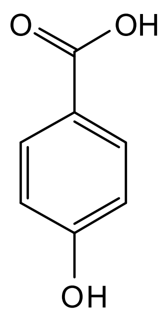






3. The molecules shown below can act as ***acids*** in different ways; each has multiple protons that might be transferred to a Lewis base. Of those protons, which is most acidic? (It might help to draw multiple acid-base reactions to answer this question.) In addition to using the qualitative guidelines we discussed in class, it might also help to consult a pK_a table.





4. The molecules shown below can act as ***bases*** in different ways; each has multiple electron pairs that might be donated to a Lewis acid. Of those lone pairs, which is most basic?