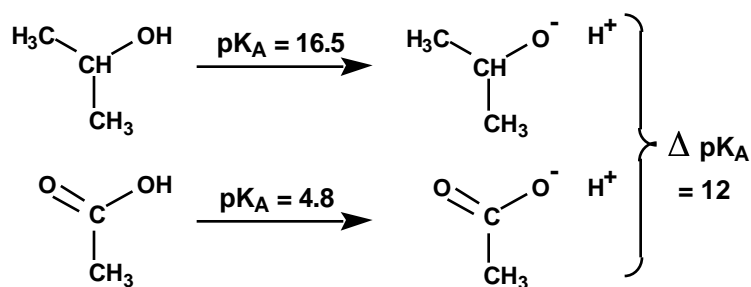
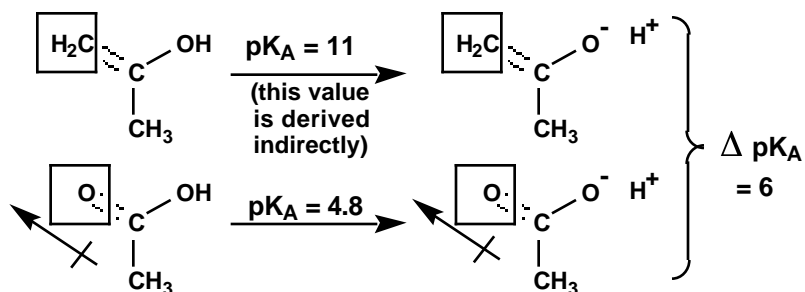


Text Related to Segment 11.04 ©2002 Claude E. Wintner

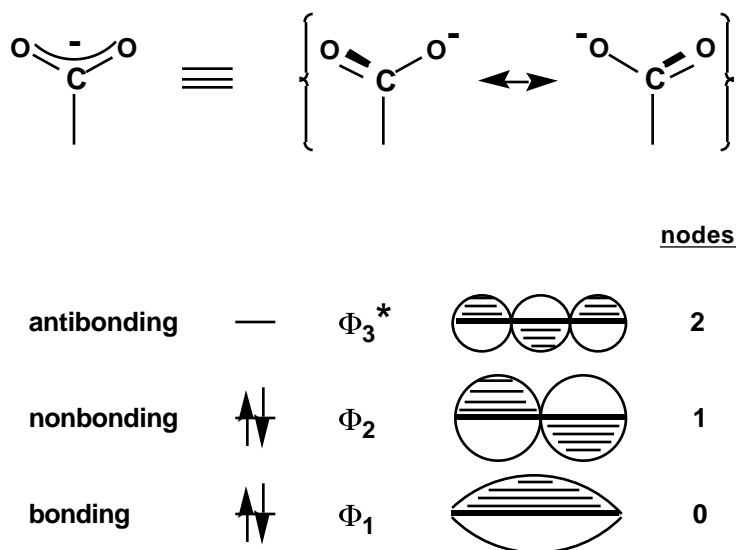
If somehow it is possible to increase the stability of a given base, then it should be true that the corresponding acid will be stronger than would be so without the added stabilization, because dissociation of the acid should be more favorable if the resultant base is more stable. In fact, this reasonable assumption is borne out by experience. A case in point is provided by the acidity of carboxylic acids. We already have alluded to a carboxylic acid as being more acidic than might be expected. Why should acetic acid, $pK_A = 4.8$, be so much more acidic than isopropanol, $pK_A = 16.5$?



There are two major reasons: an inductive effect and a delocalization effect. In this particular case each effect is approximately equally responsible for the pK_A lowering. On the one hand the additional oxygen atom in acetic acid, being more electronegative than is the carbon atom at the corresponding position in isopropanol, draws electron density away from the acidic center, rendering the bond to the proton weaker, and increasing the acidity:

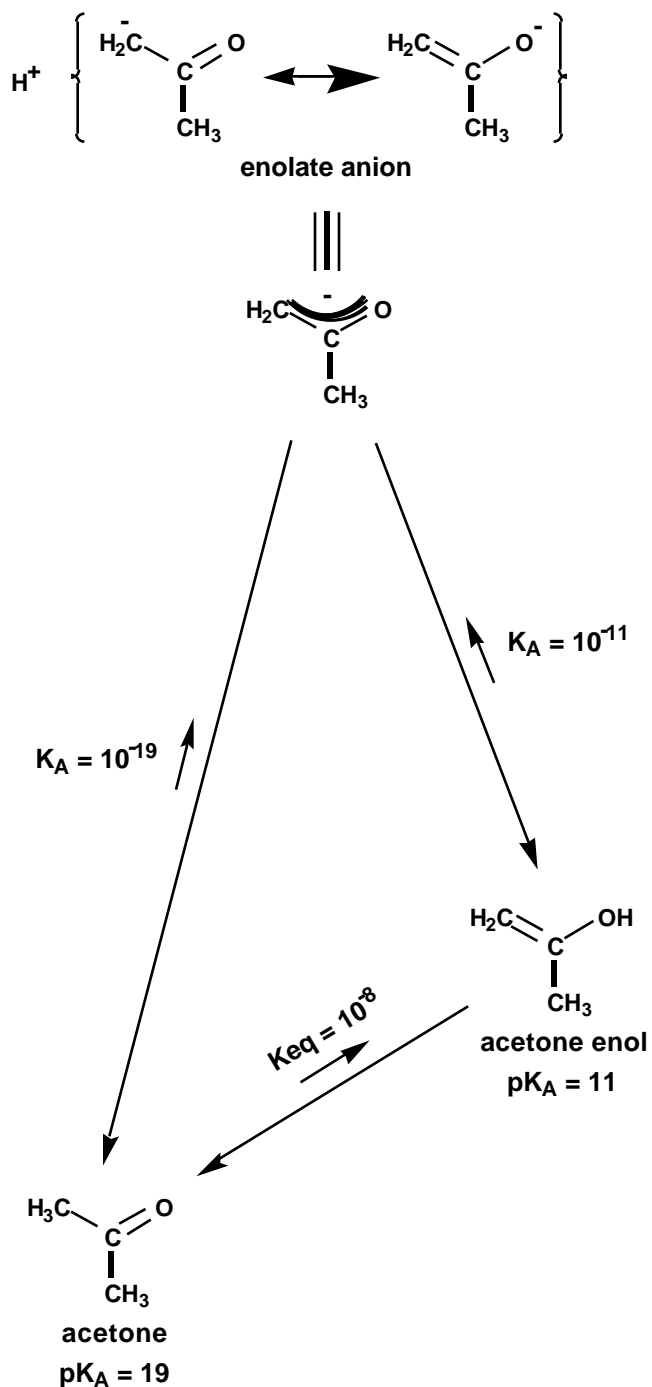


On the other hand, the double bond adjacent to the acidic center in acetic acid, but not in isopropanol, allows delocalization of the electron pair remaining when the proton is lost. The resulting favorable three-orbital-four-electron system — for which the lowest (bonding) orbital lies at a lower energy than the corresponding localized carbonyl bond — stabilizes the carboxylate anion relative to the isopropylate anion:



A closely related example — one having, as we shall see later, profound consequences for the broad class of aldol-related reactions — is acetone (2-propanone), which again is much more acidic than at first might be expected. While

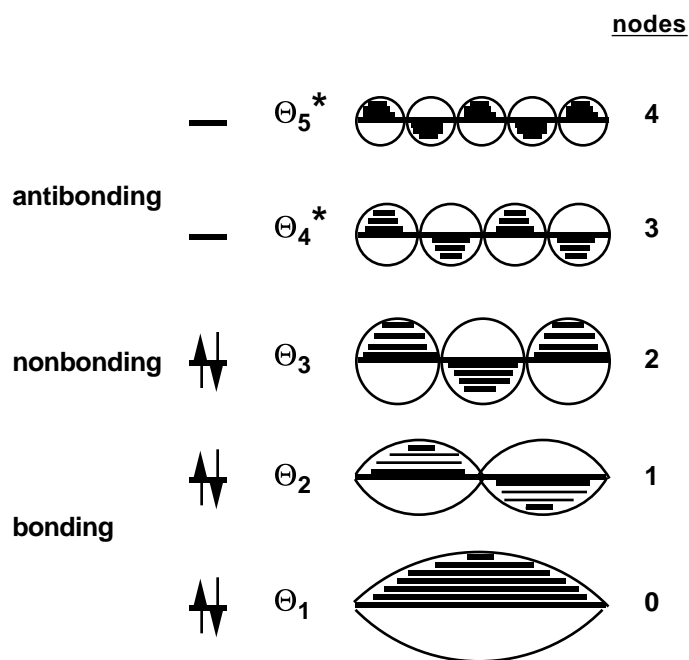
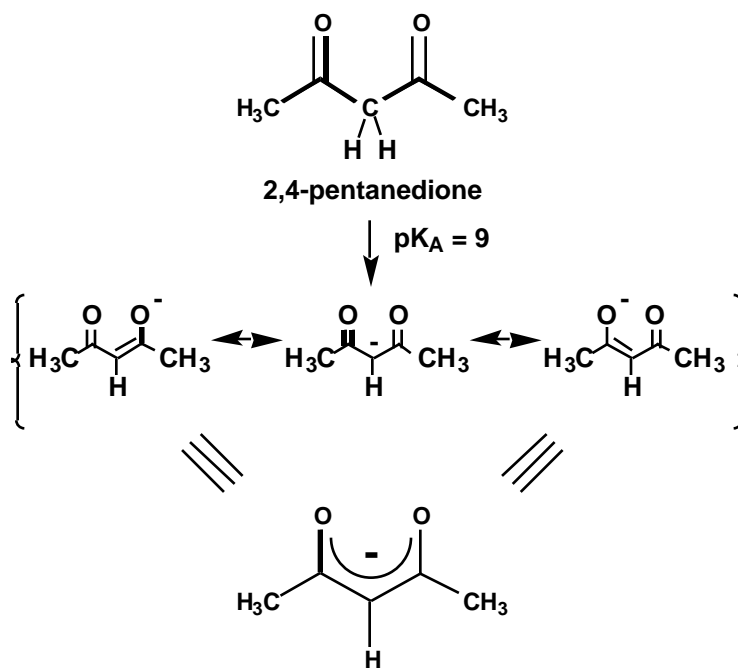
the pK_A of an unactivated methyl group is in the neighborhood of 50, that of acetone is only 19:



the ketone acetone and its enol tautomer;
 stabilization of the enolate anion as a
 three-orbital-four-electron delocalized system

Again the delocalization and inductive effects combine to endow the anion corresponding to acetone, a so-called enolate anion, with the special stability of a three-orbital-four-electron system having an electronegative terminal atom. In this case the termini of the orbital system are not equivalent; there is greater electron density at the more electronegative oxygen end. As one would expect, acetone is not as acidic as acetic acid, because the enolate anion has only a single oxygen terminus rather than two, as in the carboxylate anion. Note that the enolate anion has *two* corresponding acids: the starting ketone acetone if it is reprotonated at carbon or the so-called enol (acetone enol) if it is reprotonated at oxygen to form the isomer (also called a *tautomer*). In general, the keto tautomer is more stable than the enol tautomer; for the specific case of acetone the keto/enol ratio at equilibrium is approximately 10^8 , corresponding to a greater keto stability of some 11 kcal/mole. (In fact, we already have invoked acetone enol and the acetone enolate anion above, as part of our rationalization of the source of the acidity of acetic acid.)

The effect of enolate stabilization is seen amplified in extended systems having added conjugation. Thus, the pK_A of 2,4-pentanedione (for a hydrogen atom at C-3) is only 9. In this case the resulting, additionally stabilized, anion is a delocalized five-orbital-six-electron system:



the anion of 2,4-pentanedione is a
 five-orbital-six-electron delocalized system