Acid and Base Strengths

	Acid	Base	pKa	
Strong acid in water	$HClO_4$	ClO_4^-	-10	Strong acid in ammonia
	HI	I^-	-10	
	H_2SO_4	HSO_4^-	-10	
	HBr	Br^-	-9	
	HCl	Cl^-	-7	
	HNO_3	NO_3^-	-2	
	H_3O^+	H_2O	-1.74	
Weak acids in water	CCl_3CO_2H	$CCl_3CO_2^-$	0.52	
	HSO_4^-	SO_4^{-2}	1.99	
	H_3PO_4	$H_2PO_4^-$	2.12	
	CH_2ClCO_2H	$CH_2ClCO_2^-$	2.85	
	HF	F^-	3.17	
	HNO_2	NO_2^-	3.3	
	CH_3CO_2H	$CH_3CO_2^-$	4.75	
	$C_5H_5NH^+$	C_5H_5N	5.25	
	H_2CO_3	HCO_3^-	6.35	
	H_2S	HS^{--}	7.00	
	NH_4^+	NH_3	9.24	
	HCO_3^-	CO_3^{-2}	10.33	Weak acid in ammonia
	$CH_3NH_3^+$	CH_3NH_2	10.56	
	H_2O	OH^-	15.74	
Not an acid in water	CH_3OH	CH_3O^-	18	
	HCCH	HCC^-	25	
	NH_3	NH_2^-	34	
	CH_2CH_2	CH_2CH^-	36	Not an acid in ammonia
	CH_3CH_3	$CH_3CH_2^-$	42	

Relative Acid Base strengths are expressed by the pKa scale. A given acid will give up its proton to the base of an acid with a higher pKa value. The base of a given acid will deprotonate an acid with a lower pKa value.

Examples:

Consider the solvent water.

Water, H_2O, is the base of the hydronium ion, H_3O^+, pka -1.74. This value is greater than the pKa of HCl, -7. This means that HCl will give up its protons to water essentially completely to form the H_3O^+ cation. We call HCl a strong acid in water. One can assume that all of the HCl in a water solution is 100 percent dissociated meaning that both the hydronium ion concentration and the chloride ion concentration correspond directly to the amount of added HCl.

Acetic acid, CH_3CO_2H, has a pKa of 4.75, greater than that of the hydronium ion, but less than that of water itself, 15.74. This means that acetic acid can dissociate in water, but only to a small extent. We call acetic acid a weak acid. To calculate the actual concentration of the hydronium ion and the acetate anion in an acetic acid water solution one must carry out an equilibrium calculation. If one adds sufficient sodium hydroxide, NaOH, to a solution of acetic acid in water then the hydroxide anion will totally deprotonate the acetic acid, because the hydroxide ion is a strong base in water. The final product will be a sodium acetate solution.

Acetylene, HCCH, has a pKa value of 25 greater than that of water, 15.74. This means that HCCH can not act as an acid in water. In water there will be essentially no dissociation of HCCH, the concentration of the HCC^- anion can be assumed to be zero.

Consider the solvent ammonia.

Ammonia, NH_3, is the base of the ammonium ion, NH_4^+, pka 9.24. This value is higher than the pKa of acetic acid, 4.75. This means that acetic acid will give up its protons to ammonia essentially completely to form the NH_4^+ cation. We call acetic acid a strong acid in ammonia. One can assume that all of the acetic acid in a ammonia solution is 100 percent dissociated meaning that both the ammonium ion concentration and the acetate ion concentration corresponds directly to the amount of added acetic acid.

Acetylene, HCCH, has a pKa value of 25, greater than that of the ammonium ion, but less than that of ammona itself, 34. This means that acetylene can dissociate in ammonia, but only to a small extent. We call acetylene a weak acid in ammonia. To calculate the actual concentration of the ammonium ion and the HCC^- acetylide anion in an acetylene ammonia solution one must carry out an equilibrium calculation. If one adds sufficient sodium amide, $NaNH_2$, to a solution of acetylene in ammonia then the amide anion will totally deprotonate the acetylene, because the amide ion is a strong base in ammonia. The final product will be a sodium acetylide solution.

Ethane, CH_3CH_3, has a pKa value of 42 greater than that of ammonia, 34. This means that CH_3CH_3 can not act as an acid in ammonia. In ammonia there will be essentially no dissociation of CH_3CH_3, the concentration of the $CH_3CH_2^-$ anion can be assumed to be zero.