Classes of Weak Acids and Weak Bases

Weak acids generate a concentration of $H^+_{(aq)}$ less than that of the acid itself. Typically, weak acids ionize to only a few percent in water through an equilibrium. The weak acid ionization constant, K_a, allows the equilibrium to be quantified.

There are four classes of weak acids:

(a) NEUTRAL PROTON DONORS -- the typical weak acids such as acetic acid, benzoic acid, hydrofluoric acid, etc.

$$HC_2H_3O_{2(aq)} \rightleftharpoons H^+_{(aq)} + C_2H_3O_2^-{}_{(aq)} \qquad K_a = 1.7 \times 10^{-5}$$

(b) ACIDIC HYDROGEN-CONTAINING ANIONS OF POLYPROTIC ACIDS.

$H_2PO_4^-$ $K_{a2} = 6.2 \times 10^{-8}$; HSO_4^- $K_a = 1.1 \times 10^{-2}$; $HC_2O_4^-$ $K_a = 5.1 \times 10^{-5}$

(c) CONJUGATE ACIDS OF WEAK BASES -- most notably $NH_4^+{}_{(aq)}$

$NH_4^+{}_{(aq)} \rightleftharpoons NH_{3(aq)} + H^+_{(aq)}$ and $K_a(NH_4^+) = K_w / K_b(NH_3)$

(d) CATIONS WITH A HIGH POSITIVE CHARGE which hydrolyze in water (react with water).

$Al^{3+}_{(aq)}$, $Fe^{3+}_{(aq)}$, $Sn^{4+}_{(aq)}$, etc.

$[Al(H_2O)_5(\mathbf{H_2O})]^{3+} \rightleftharpoons [Al(H_2O)_5(\mathbf{OH})]^{2+} + \mathbf{H^+}_{(aq)}$ $K_a(Al^{3+}) = 1.1 \times 10^{-5}$

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Weak bases generate a concentration of $OH^-_{(aq)}$ lower than that of the base itself. Weak bases generate the hydroxide ion by reaction with water (hydrolysis) which can be described as an equilibrium quantified through K_b.

$$\text{weak base}_{(aq)} + H_2O_{(l)} \rightleftharpoons H^+(\text{weak base})_{(aq)} + OH^-_{(aq)}$$

(the conjugate acid of the weak base)

There are two classes of weak bases:

(a) NITROGEN BASES -- typically aqueous ammonia and organic compounds that contain one or more nitrogen atoms each holding a non-bonding pair of electrons such as: methyl amine, CH_3NH_2, pyridine, C_5H_5N and hydrazine, N_2H_4.

$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$ $K_b = 1.8 \times 10^{-5}$

(b) CONJUGATE BASES OF WEAK ACIDS -- the anions of weak acids such as, the acetate ion, $C_2H_3O_2^-$; fluoride ion, F^-; nitrite ion, NO_2^-, etc. A solution of $NaC_2H_3O_2$ is basic because of the high affinity the acetate ion has for a proton.

$C_2H_3O_2^-{}_{(aq)} + H_2O_{(aq)} \rightleftharpoons HC_2H_3O_{2(aq)} + OH^-_{(aq)}$ $K_b = K_w / K_a(HC_2H_3O_2)$