Relationship Btwn K_a and K_b

$$\cancel{HClO} + H_2O \rightleftharpoons H_3O^+ + \cancel{ClO^-}$$

$$K_a = \frac{[H_3O^+][ClO^-]}{[HClO]}$$

+

$$\cancel{ClO^-} + H_2O \rightleftharpoons \cancel{HClO} + OH^-$$

$$K_b = \frac{[HClO][OH^-]}{[ClO^-]}$$

What's relationship btwn the K_a and K_b?

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

$$K_w = [H_3O^+][OH^-]$$

$$= 10^{-14}$$

if we add 2 rxn, we must MULTIPLY their equilibrium constants

$$K_a \times K_b = \frac{[H_3O^+][\cancel{ClO^-}]}{[\cancel{HClO}]} \times \frac{[\cancel{HClO}][OH^-]}{[\cancel{ClO^-}]}$$

$$= [H_3O^+][OH^-] = K_w$$

$$\therefore K_a \cdot K_b = K_w$$

If $K_a = 3.0 \times 10^{-8}$

$$K_b = \frac{K_w}{K_a} = \frac{10^{-14}}{3.0 \times 10^{-8}} = 3.3 \times 10^{-7}$$

$pK_a = -\log K_a$ $\quad K_a = 10^{-pK_a}$ $\quad pK_a = 3.5$

$K_a = 10^{-3.5}$

$pK_b = -\log K_b$

Since $K_a \times K_b = K_w = 10^{-14}$

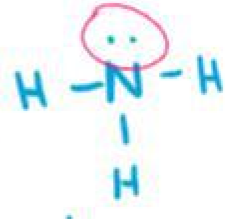
$$\underbrace{-\log K_a}_{pK_a} + \underbrace{(-\log K_b)}_{pK_b} = -\log(10^{-14})$$

$$pK_a + pK_b = 14$$

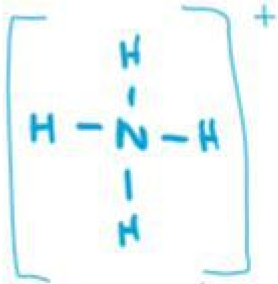
Weak Bases

1. They can be a neutral atom w/ a lone pair (ready to accept a proton)

↳ ex: NH_3 →



base



conj. acid

2. Anions that are conjugate bases of weak acids

↳ NOT conj. bases of strong acids

→ ex: Cl^- (NOT weak base) → HCl ↓ strong acid

Ex: Are the following species weak bases?

① F^- $\rightarrow$ HF is the conj. acid

↳ but it's a weak acid

$\therefore$ F^- IS a weak base!

② NO_3^- $\rightarrow$ HNO_3 is conj. acid

↳ it's a STRONG ACID

$\therefore$ F^- ISN'T a weak base!

③ CO_3^{2-} $\rightarrow$ HCO_3^- is conj. acid

↳ it's a weak acid

$\therefore$ CO_3^{2-} IS a weak base

Identifying Weak Acids

1. Neutral Proton Donors
   - ↳ not strong acids
     - ex: $HClO$, CH_3COOH
2. Anions of Polyprotic acids (depending on K_a)
   - ex: HSO_4^-
3. Cations that are conj. acid of weak base
   - ex: NH_4^+
4. Small, highly charged metal cations
   - ex: Fe^{3+}, Al^{3+}

- small, highly charged transition + post-transition metals form hydrated cations
  - ↳ water attached to the metal is more acidic than free water molecules, making the hydrated ions acidic

☆ Cations of strong bases DO NOT act as acids

- ex: Na^+, Ca^{2+}

Ex: $NH_4Cl \rightleftharpoons \underbrace{NH_4^+}_{\text{conj. acid of weak base, } NH_3} + \underbrace{Cl^-}_{\text{not a base bc HCl is strong acid}} \Rightarrow$ acidic solution