Acids and Bases IV continued

Weak Bases (WB)

- Like WA, WB have an equilibrium constant called the base dissociation constant, K_b
- Equilibrium calculations work the same as for acids, using the base dissociation constant instead

$$\underset{\text{weak base}}{B\,(aq)} + H_2O\,(l) \rightleftharpoons \underset{\text{conjugate acid}}{BH^+\,(aq)} + OH^-\,(aq)$$

$$K_b = \frac{[OH^-][BH^+]}{[B]}$$

What is the pH of 0.15 M NH_3 @ 25°C?

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

$$k_b = \frac{[NH_4][OH^-]}{[NH_3]} = 1.8 \times 10^{-5}$$

	NH_3 (M)	NH_4^+ (M)	OH^- (M)
I	0.15	0	0
C	−x	+x	+x
E	0.15−x	x	x

$$k_b = \frac{[NH_4][OH^-]}{[NH_3]} = \frac{x^2}{0.15-x} = 1.8 \times 10^{-5}$$

If we assume that $x << 0.15$, then $0.15 - x = 0.15$

Then: $1.8 \times 10^{-5} = \dfrac{x^2}{0.15}$ $\quad x = 1.6 \times 10^{-3}$

Daily dose of quinine for malarial prevention is 2100 mg. What is pH of a gin and tonic that contains one dose of quinine in 100 mL?

$$2.1\,g \times \frac{1\,mol}{324\,g} = 6.48 \times 10^{-3}\,mol$$

$$= 6.48 \times 10^{-2}\,M$$

$pK_{b_1} = 5.1$ $\quad pK_{b_2} = 9.7$

$$K_b = \frac{[BH^+][OH^-]}{[B]} = \frac{x^2}{0.0648 - x} = 7.9 \times 10^{-6}$$

Assume that $x << 0.0648$, then $0.0648 - x = 0.0648$

so: $7.9 \times 10^{-6} = \frac{x^2}{0.0648}$, $x = 7.15 \times 10^{-4}$

- x is $[OH^-]$, so $-\log(x)$ is pOH (pOH = 3.15)
- pH = 14 − pOH = 10.85

Solution of NH_3 has pH = 11.30. What is its concentration? $K_b = 1.8 \times 10^{-5}$

$$NH_3\,(aq) + H_2O\,(\ell) \rightleftharpoons NH_4^+\,(aq) + OH^-\,(aq)$$

	NH_3	NH_4	OH^-
I	y	0	0
C	-2.0×10^{-3}	$+2.0 \times 10^{-3}$	$+2.0 \times 10^{-3}$
E	$y - 2.0 \times 10^{-3}$	2.0×10^{-3}	2.0×10^{-3}

$$K_b = 1.8 \times 10^{-5} = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

$$= \frac{(2.0 \times 10^{-3})^2}{y - 2.0 \times 10^{-3}}$$

Assume: $\frac{(2.0 \times 10^{-3})^2}{y} = 1.8 \times 10^{-5}$

$y = 4.5\,M$

pH = 11.30

pOH = 2.7

$[OH^-] = 2.0 \times 10^{-3}$

Relationship between K_b and K_a

- For conjugate acid-base pair,

$$K_a \times K_b = K_w$$

- Therefore, if you know one of them, you can calculate the other

Novocain is the hydrochloride salt of the base procaine.

$$C_{13}H_{20}N_2O_2\,(aq) + HCl \rightarrow [HC_{13}H_{20}N_2O_2]\,Cl^-\,(aq)$$

procaine — Novocaine, $K_a = 1.4 \times 10^{-9}$

What is the pH of a 0.015M sln of procaine?

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{1.4 \times 10^{-9}} = 7.14 \times 10^{-6}$$

Acid-Base Properties of Salt

- Most salts are strong electrolytes, producing ions in water
- Many ions react with H_2O to produce H^+ or OH^-
- A systematic analysis of a salt allows prediction of whether an aqueous solution will be acidic, basic, or neutral
  - The cation can be acidic or neutral
  - The anion can be acidic, basic, or neutral

In class question ⇒ You dissolve NaCl in water. what is pH of the resulting sln?

$$NaCl\,(aq) \rightarrow Na^+\,(aq) + Cl^-\,(aq)$$

- Na^+ does not gain or accept H^+
- Cl^- does not gain or accept H^+

Neither ion has acid-base character; the pH = 7.0

In class question ⇒ You dissolve NH_4Cl in water. What is pH of solution?

$$NH_4Cl\,(aq) \rightarrow NH_4^+\,(aq) + Cl^-\,(aq)$$

- NH_4^+ is the conjugate acid of NH_3, a weak base
- Cl^- does not gain or accept H^+

NH_4^+ is a weak acid, so the pH < 7.0

Predicting Acid – Base Properties of Salt

- What ions are formed when the salt dissolves?
- Is the cation an acid?
  - Does it have H^+ to donate?
- Is the anion a base or an acid?
  - Can it accept H^+? (base)
  - Can it donate H^+? (acid)
- Compare K_a to K_b if necessary
  - Bigger equilibrium constant will dominate

- The anion from a monoprotic strong acid does not act as a base.
  ie. Cl^-, Br^-, I^-, NO_3^-, ClO_3^-, ClO_4^-
- The cation from a strong base does not act as an acid
  ie. Li^+, Na^+, K^+, Ca^{2+}, Sr^{2+}

"Easy Cases"

Cation	Anion	Type of solution	pH
Weak Acid (NH_4^+, Fe^{3+})	From a strong acid (Cl^-, NO_3^-, ClO_3^-)	Acidic	< 7.0
From a Strong base (Na^+, Ca^{2+})	Weak base (F^-, HCO_3^-)	Basic	> 7.0
From a Strong base (Na^+, Ca^{2+})	From a strong acid (Cl^-, NO_3^-, ClO_3^-)	Neutral	$= 7.0$