Announcements – Lecture XV – Thursday, Mar 22nd

1. iClicker:  Pick any letter a-e

2. Quiz 6: Place in basket on front bench.

3. Exam II: **Moved to Saturday, April 7th.**

16.4 Estimating the pH of Acid and Base Solutions

pH of a Weak Base – Approx Method

Calculate the **pH** of a 0.372 M aqueous solution of isoquinoline (C_9H_7N, Kb = 2.5×10^{-9})

pH = ?.48

	C_9H_7N	+	H_2O	(⇌)	$C_9H_7NH^+$	+	OH^-
I	0.372				0		0
C	-x				x		x
E	0.372 - x				x		x

[B] > 100Kb, thus 0.372 - x ≈ 0.372

$$K_b = \frac{[C_9H_7NH^+][OH^-]}{[C_9H_7N]}$$

$$2.5 \times 10^{-9} = \frac{x \cdot x}{0.372}$$

$$x^2 = 0.372(2.5 \times 10^{-9})$$

$$x = \sqrt{0.372(2.5 \times 10^{-9})}$$

$$= 3.05 \times 10^{-5} = [OH^-]$$

$$pOH = -\log_{10}(3.05 \times 10^{-5})$$

$$= 4.52$$

$$pH + pOH = 14 \quad @\ 25^\circ C$$

$$pH + 4.52 = 14$$

$$pH = 9.48$$

16.5 Acid-Base Properties of Salts

Hydrolysis – Neutral Cations and Anions

Hydrolysis

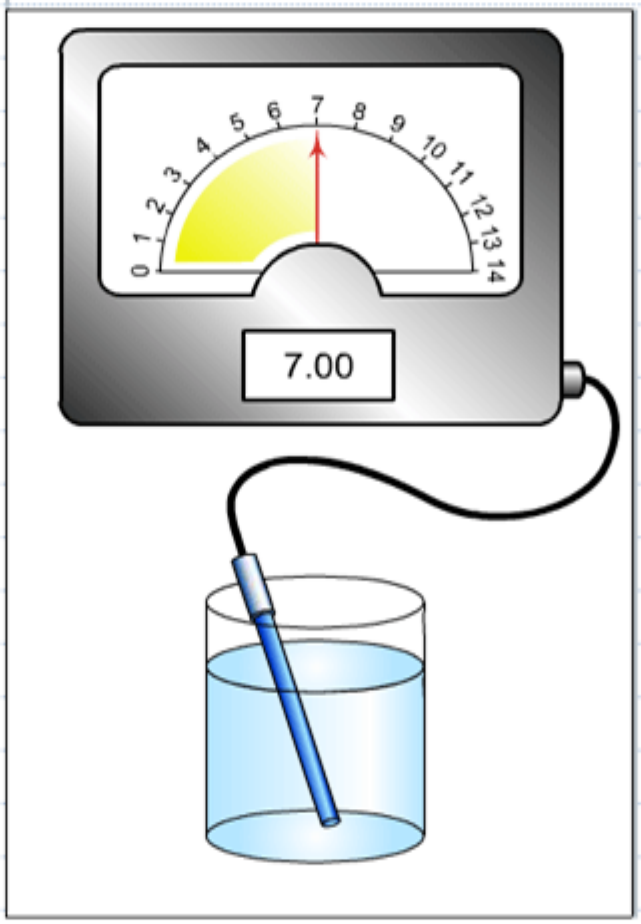
Cation	Anion
◉ Na^+	◉ Cl^-
○ NH_4^+	○ F^-
○ $C_5H_5NH^+$	○ CN^-
	○ NO_2^-
	○ ClO^-

Concentration

0.01 M

Salt: NaCl

pH = 7.00



Neutral Cations:

Those cations associated with the six strong bases.

NaOH : Na^+

KOH : K^+

Non neutral cations are all potential weak acids, ie NH_4^+

Neutral Anions:

Those anions associated with the six strong acids.

HCl : Cl^-

HBr : Br^-

Non neutral anions are all potential weak bases, ie F^-

16.5 Acid-Base Properties of Salts

Acid–Base Properties of Salts

An aqueous solution of **NaClO** is expected to be:

a) Acidic
b) Basic ✓
c) Neutral

$NaClO_{(aq)} = Na^+ + ClO^-$

↳ Neutral cation.

↳ Non neutral anion ... basic.

$ClO^- + H_2O_{(l)} \rightleftharpoons HClO_{(aq)} + OH^-$

16.5 Acid-Base Properties of Salts

Acid–Base Properties of Salts

An aqueous solution of **ammonium nitrite** is expected to be:

$K_a\ HNO_2 = 4.5 \times 10^{-4}$ $K_b\ NH_3 = 1.8 \times 10^{-5}$

a) Acidic ✓
b) Basic
c) Neutral

Ammonium nitrite = NH_4NO_2

$$NH_4NO_2(aq) = NH_4^+ + NO_2^-$$

↳ non neutral cation.
↳ non neutral anion.

$NH_4^+ + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+$ $K_{NH_4^+} = ?$

$K_a K_b = 1 \times 10^{-14}$

$K_{NH_4^+} = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$

$NO_2^- + H_2O(l) \rightleftharpoons HNO_2(aq) + OH^-$ $K_{NO_2^-} = ?$

$K_a K_b = 1 \times 10^{-14}$

$K_{NO_2^-} = \frac{1 \times 10^{-14}}{4.5 \times 10^{-4}} = 2.2 \times 10^{-11}$

$K_{NH_4^+} > K_{NO_2^-}$ thus expect solution to be acidic.

16.5 Acid-Base Properties of Salts

Determining pH of a Salt Solution

What is the **pH** of an 0.432M aqueous solution of NaCN
Ka HCN = 4.0×10^{-10}.

$NaCN(aq) = Na^+ + CN^-$

	CN^-	+	H_2O	⇌	HCN	+	OH^-
I	0.432				0		0
C	-x				x		x
E	0.432 - x				x		x

$K_a K_b = 1 \times 10^{-14}$

$K_{CN^-} = \frac{1 \times 10^{-14}}{4.0 \times 10^{-10}} = 2.5 \times 10^{-5}$

$[CN^-] > 100(2.5 \times 10^{-5})$ thus $0.432 - x \approx 0.432$

$K_b = \frac{[HCN][OH^-]}{[CN^-]}$

$2.5 \times 10^{-5} = \frac{x \cdot x}{0.432}$

$x^2 = 0.432(2.5 \times 10^{-5})$

$x = \sqrt{0.432(2.5 \times 10^{-5})} = 3.29 \times 10^{-3} = [OH^-]$

$pOH = -\log_{10}(3.29 \times 10^{-3}) = 2.48$

$pH + pOH = 14$ @ 25°C

$pH + pOH = 14$

$pH + 2.48 = 14$

$pH = 11.52$

17.1 Acid-Base Reactions

Types of Reactions

Reaction	Example	pH at Eq	Extent
Strong acid + strong base	$HCl(aq) + NaOH(aq) \rightarrow H_2O(\ell) + NaCl(aq)$	7	100%
Strong acid + weak base	$HCl(aq) + NH_3(aq) \rightarrow NH_4Cl(aq)$	< 7	100%
Strong base + weak acid	$NaOH(aq) + HClO(aq) \rightarrow H_2O(\ell) + NaClO(aq)$	> 7	~100%
Weak acid + weak base	$HClO(aq) + NH_3(aq) \rightleftarrows NH_4ClO(aq)$	Depends on Ka Vs Kb	?

SA + SB : $NaCl(aq) = Na^+ + Cl^-$: Both cation and anion are neutral : pH = 7

SA + WB : $NH_4Cl(aq) = NH_4^+ + Cl^-$: NH_4^+ is a weak acidic cation : pH < 7

$NH_4^+ + H_2O(l) \Leftrightarrow NH_3(aq) + H_3O^+$

WA + SB : $NaClO(aq) = Na^+ + ClO^-$: ClO^- is a weak basic anion : pH > 7

$ClO^- + H_2O(l) \Leftrightarrow HClO(aq) + OH^-$

WA + WB : $NH_4ClO(aq) = NH^+ + ClO^-$: Both cation and anion are weak acid and weak base ions.

$NH_4^+ + H_2O(l) \Leftrightarrow NH_3(aq) + H_3O^+$: Ka

$ClO^- + H_2O(l) \Leftrightarrow HClO(aq) + OH^-$: Kb

pH depends on which K is larger.