March 6, 2002

- ✓***No Labs This Week!***
- ✓**Exam #2**
  - ✓Conflict? Email me *this week* to schedule alternate time
  - ✓Old exam #2 answers now online
- ✓**Sunday Review Session?**
- ✓**Demo today!**
- ✓**Quiz Friday!**

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Conjugate A/B *Strengths*

- Sum of pK_a and pK_b always = 14.00 (at 25 °C)
- If an *acid* (HA) has a small pK_a, its **conjugate base** (A^-) will have a large pK_b
- Conjugate acid/base strengths are *complementary*

Example: **Acetic Acid**

$K_a = 1.76 \times 10^{-5}$

$K_b = K_w/K_a = 1.0 \times 10^{-14}/1.76 \times 10^{-5} = 5.7 \times 10^{-10}$ (for Ac^-)

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Strong versus Weak

- If $K_a >> 1$, acid is "completely" dissociated in water:

Strong Acid

$$HCl\ (aq) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + Cl^-\ (aq)$$

Similarly for a base,

Strong Base

- If $K_b >> 1$, base dissociation is "complete":

$$NaOH\ (aq) \rightarrow Na^+\ (aq) + OH^-\ (aq)$$

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Is the Conjugate Base of a Strong Acid, Strong or Weak?

$$HCl\ (aq) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + Cl^-\ (aq)$$

conjugate base

What is K_b for Cl^-?

$$K_b\ (Cl^-) = K_w / K_a\ (HCl)$$

Substituting $K_a \approx 10^7$:

$$K_b \approx 10^{-14}/10^7$$

$$K_b \approx 10^{-21}$$

Cl^- is a *weaker base* than **H_2O**! ($K_b = K_w = 10^{-14}$)

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Acid/Base Strength Depends on the Solvent

In water, HCl is a *strong acid:*

$HCl\ (aq) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + Cl^-\ (aq)$ $\quad K_a \approx 10^7$

So: Cl^- is a *weaker base* than H_2O
HCl is a *stronger acid* than H_3O^+

But, in ether, HCl is a *weak acid:*

$HCl\ (aq) + (CH_3CH_2)_2O\ (l) \leftrightarrows (CH_3CH_2)_2OH^+\ (aq) + Cl^-\ (aq)$

So: Cl^- is a *stronger base* than ether
HCl is a *weaker acid* than $(CH_3CH_2)_2OH^+$ $\quad K_a << 1$

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The Leveling Effect

The *strongest acid* in any solvent is the conjugate acid of the solvent

- In water, the strongest acid is H_3O^+
- All acids that *dissociate completely* in water are ***leveled*** to the strength of H_3O^+
- All *strong acids* will seem *equally strong*

Can apply similar reasoning to base strengths

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Example: NH_3 (l) as solvent

What is the strongest acid in an NH_3 (l) solvent?

$$NH_3\ (l) + NH_3\ (l) \leftrightarrows \underset{\text{strongest acid}}{NH_4^+\ (aq)} + \underset{\text{strongest base}}{NH_2^-\ (aq)}$$

In water, K_a of $NH_4^+ = K_w/K_b \approx 10^{-14}/10^{-5} = 10^{-9}$

(K_b of NH_3)

- So, any acids with a K_a in water $> 10^{-9}$ will be *equally strong* ("leveled") in liquid ammonia

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