

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!**

1

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**

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

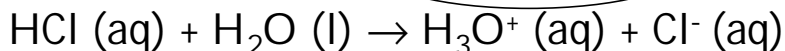
$$K_b = K_w / K_a = 1.0 \times 10^{-14} / 1.76 \times 10^{-5} = 5.7 \times 10^{-10} \text{ (for } Ac^- \text{)}$$

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Strong versus Weak

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

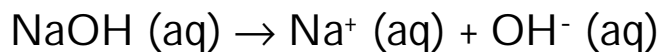
Strong Acid



Similarly for a base,

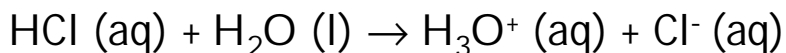
Strong Base

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



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



conjugate base

What is K_b for Cl^- ?

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

Substituting $K_a \approx 10^7$:

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

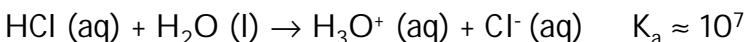
$$K_b \approx 10^{-21}$$

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

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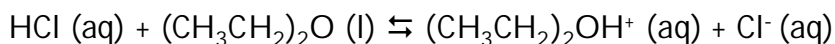
Acid/Base Strength Depends on the Solvent

In water, HCl is a *strong acid*:



So: Cl⁻ is a *weaker base* than H₂O
HCl is a *stronger acid* than H₃O⁺

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



So: Cl⁻ is a *stronger base* than ether
HCl is a *weaker acid* than (CH₃CH₂)₂OH⁺ $K_a \ll 1$

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The Leveling Effect

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

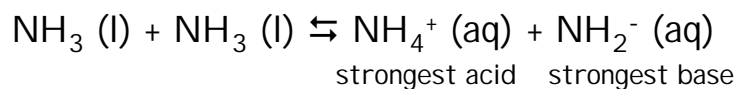
- In water, the strongest acid is H₃O⁺
- All acids that *dissociate completely* in water are **leveled** to the strength of H₃O⁺
- All *strong acids* will seem *equally strong*

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?



In water, K_a of $\text{NH}_4^+ = K_w / K_b \approx 10^{-14} / 10^{-5} = 10^{-9}$
of NH_3

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