Acid/Base Behavior and Structure

Background

HCl

HF

NaOH

CH_3COOH

CH_3OH

CH_4

Acid/Base Behavior and Structure

Factors that Affect Acid Strength

- The H-* bond * = Some other atom or molecule
- There are 3 factors that we need to keep track of to understand acidic strength
  - The **polarity** of the H-* bond (how shifted it is)
    - The more polar the bond, the weaker the bond and the stronger the acid
  - The **strength** of the H-* bond (how strong the attraction is)
    - The weaker the bond, the stronger the acid
  - The **stability** of the conjugate base ($*^-$)
    - The more stable the conjugate base, the stronger the acid

Acid/Base Behavior and Structure

General Trends

- Binary Acids
  - An acid composed of hydrogen and another atom type (often a halogen)
    - HX acids
  - The strength of the binary acids depends most on HX <u>bond strength</u>
    - The *stronger* the HX bond, the *weaker* the acid
    - Within a group, the HX bond weakens as X increases in size = stronger acid
      - Which will be stronger
        - HCl or HF?
        - H_2S or H_2O?
  - The strength of the binary acids also depends on <u>bond polarity</u>
    - The strength of the acid *increases* as the electronegativity of X *increases*
      - Which will be stronger
        - NH_3 or CH_4?
        - NH_3 or SiH_4
  - *The strength of binary acids is more dependent on bond strength than polarity*

Acid/Base Behavior and Structure

General Trends

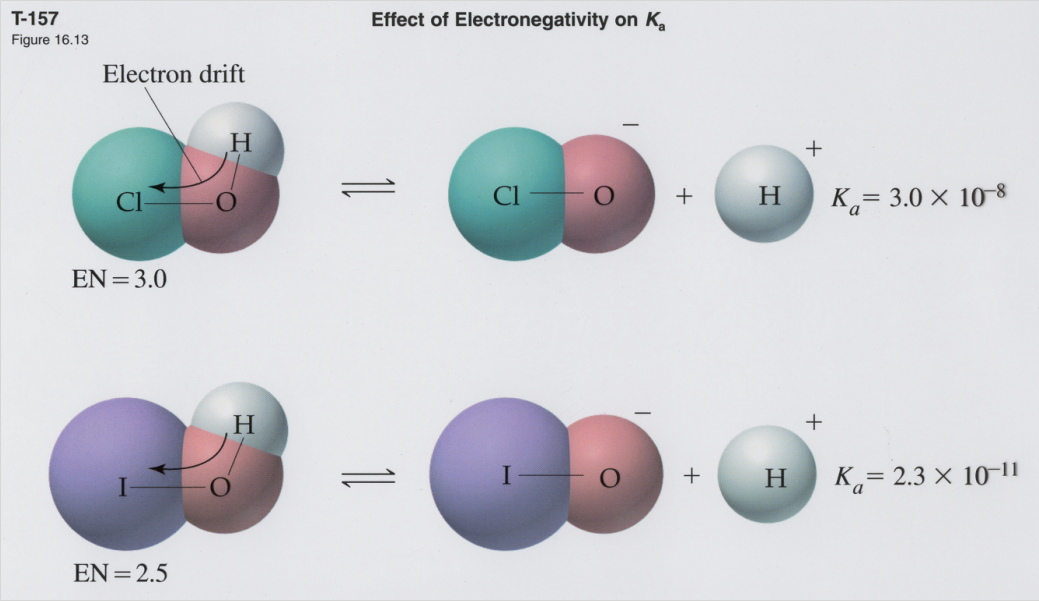
- Oxyacids
  - Acids which contain 1 or more OH groups
  - These OH groups also exists in many bases and alcohols
  - What determines when the OH group will be acidic, basic or alcoholic?
    - To understand this, let consider species Y bonded to an OH (and other atoms)

- If Y is a metal
  - Low electronegativity
  - Electrons are completely transferred to O
  - Ionic OH^- is formed
  - Basic

Acid/Base Behavior and Structure

General Trends

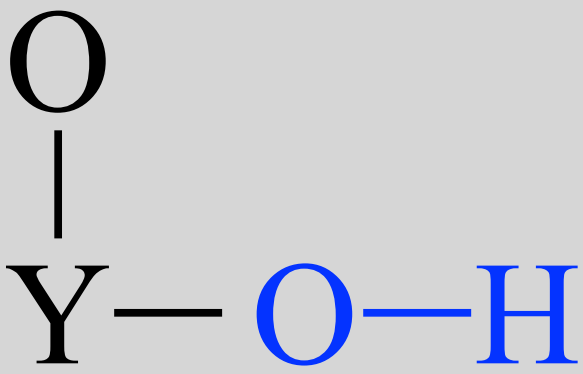
- If Y is a nonmetal
  - The Y-O bond is covalent
  - OH^- is not formed readily
  - These substances are either acidic or neutral (alcohols)
    - As the electronegativity of Y increases, the acidity increases, due to drift
      - The O-H bond becomes more polar



Acid/Base Behavior and Structure

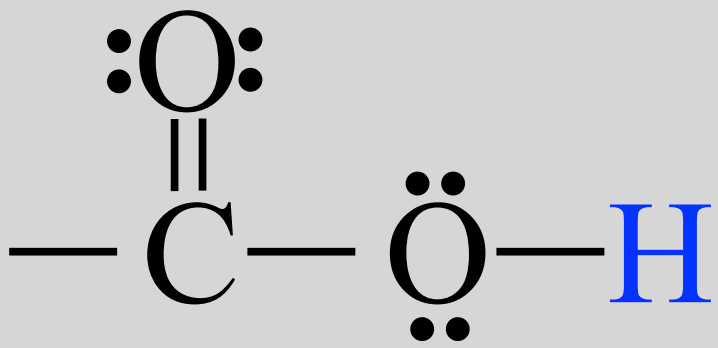
General Trends

- Many times, Y is bonded to more oxygen atoms
  - These additional oxygen (with high electronegativities) make the O-H bond more polar
  - This increased polarity creates stronger acids



Acid/Base Behavior and Structure

A Special Example of an Oxyacid



- Carboxylic Acid
  - Carboxyl group
    - COOH
  - Largest category of organic acids
    - Acetic acid
    - Formic acid
    - Acetylsalicylic acid
  - Two factors make COOH acidic
    - The additional oxygen makes the O-H bond more polar
    - The COO^- anion is resonance stabilized, and therefore more stable

Background

HCl

HF

NaOH

CH_3COOH

CH_3OH

CH_4

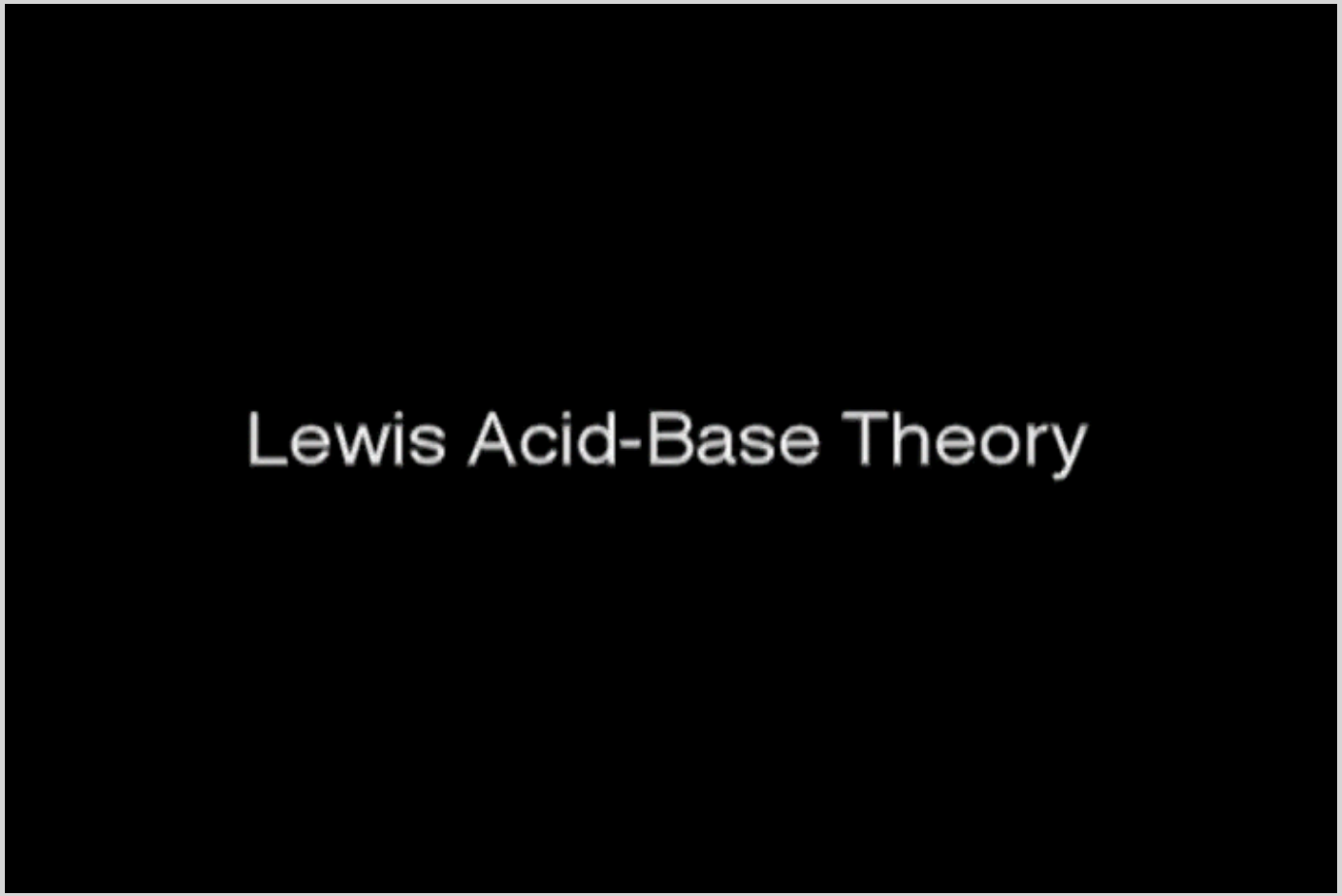
Acid/Base Behavior and Structure

A Word on Lewis Acids/Bases

- Rather than focus on the transfer of protons, Lewis (as you might suspect, or remember) defined acids and bases by their ability to accept or donate electron pairs
  - A Lewis base is an electron pair donator
  - A Lewis acid is an electron pair acceptor
- These definitions make intuitive sense, since the B/L definitions define acid as proton (+) donors and bases as proton (+) acceptors.
  - Every substance we have identified as an acid or base fits within the Lewis definition
  - The Lewis definition increases the number of species that qualify as acids or bases.
- See the end of chapter 16 for more

Acid/Base Behavior and Structure

A Word on Lewis Acids/Bases



Acid/Base Behavior and Structure

Homework

- 16.87 - How does the acid strength of an oxyacid depend on (a) the electronegativity of the central atom; (b) the number of non-protonated oxygen atoms in the molecule?
- 16.88 - (a) Why is NH_3 a stronger base than H_2O? (b) Why is NH_3 a strong base than CH_4?
- 16.93 / 16.95 / 16.97 / 16.98